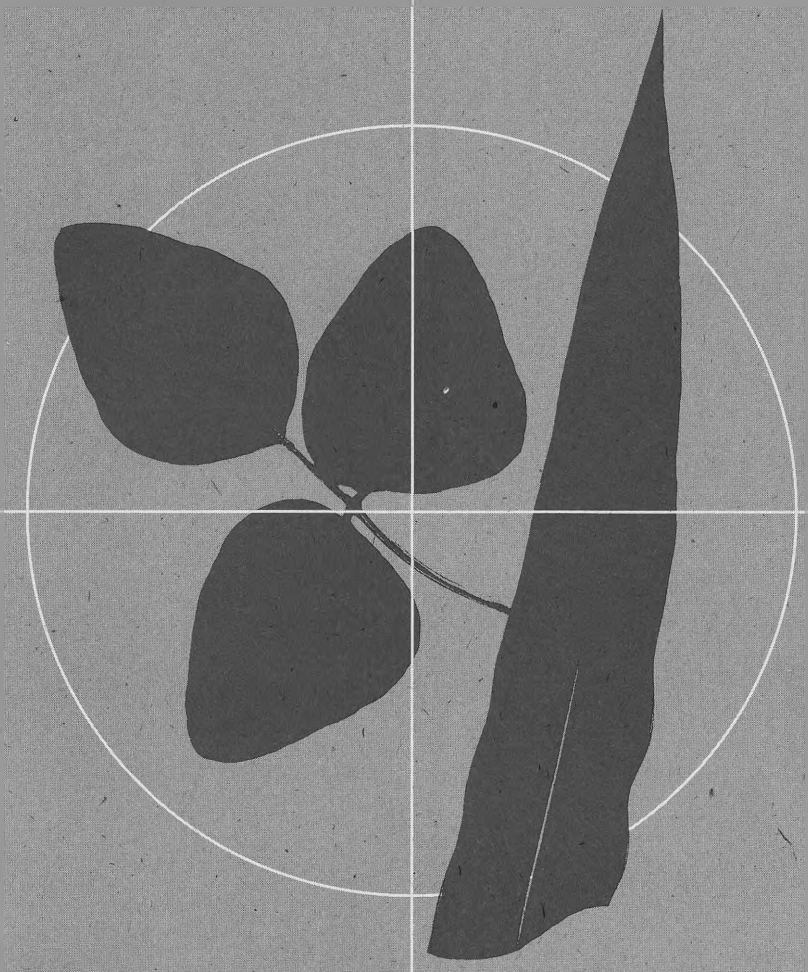
2008 Illinois Agricultural Pest Management Handbook



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The information in this handbook was prepared by specialists employed by the University of Illinois at Urbana-Champaign, College of Agricultural, Consumer and Environmental Sciences; and University of Illinois Extension. The information is revised extensively every year. **Because laws, regulations, pest-management practices, and pest-control products change significantly from year to year, out-of-date copies of this handbook may contain recommendations that are no longer legal or appropriate for the current calendar year.** The suggestions in this handbook should be used during 2008 only.

University of Illinois Extension assumes no liability for the recommendations for using pesticides that are included in this handbook. These recommendations are incomplete; therefore, they should be used only as guidelines. Complete instructions for the use of a specific pesticide are on the pesticide label. Read and follow the label directions and precautions before applying any pesticides. The pesticide user is responsible for applying pesticides according to label directions, as well as for problems that may arise through misapplication or misuse of the pesticide.

Not all pesticides registered for crop pests are included in this handbook. Effective pesticides that do not present an undue hazard to the user and the environment are suggested whenever possible. Trade names have been used for clarity, but their use does not constitute an endorsement by the University of Illinois, nor does it imply discrimination against other products.

Label changes, product cancellations, and changes in recommendations may have occurred since the publication of this handbook. Check with your nearest Extension office if you are in doubt about a pesticide that you plan to use. Announcement of new registrations, label changes, and changes in recommendations will be made through newsletters and appropriate media sources.

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EXTENSION

College of Agricultural, Consumer and Environmental Sciences

College of Agricultural, Consumer and Environmental Sciences
University of Illinois at Urbana-Champaign

Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Dennis Campion, Director, University of Illinois Extension, University of Illinois at Urbana-Champaign. University of Illinois Extension provides equal opportunities in programs and employment.

mo/11/07; 1M United Graphics

ISBN 1-883097-59-2

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Acknowledgments

The compilation and publication of this handbook require considerable coordination and cooperation among several units in the College of Agricultural, Consumer and Environmental Sciences at the University of Illinois at Urbana-Champaign. Without the dedication of the individuals involved in this effort, the handbook could never be published. The following people worked with authors to produce the *2008 Illinois Agricultural Pest Management Handbook*.

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Contents

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Insect Pest Management for Field and Forage Crops

This chapter focuses on the use of insecticides for control of insects that attack field and forage crops in Illinois. Although effective, practical, nonchemical control measures are strongly encouraged, insecticides often are the only efficient tool for responding to insect pest outbreaks. We recommend that insecticides be used only to supplement a completely integrated pest management (IPM) program that includes the use of multiple control tactics.

The guidelines provided in this chapter are based upon research results from the University of Illinois, College of Agricultural, Consumer, and Environmental Sciences; other land-grant universities; and the U.S. Department of Agriculture. The information in the handbook is revised annually and is intended for use during the current calendar year only.

The insecticides included in this chapter have been registered by the U.S. Environmental Protection Agency (USEPA). However, not all products registered for control of crop insect pests are included. *Effective insect-control products that do not present an undue hazard to the user or the environment are suggested whenever possible.*

When this publication was prepared, only currently registered products were included. New registrations and changes in registration, labels, and recommendations will be announced through appropriate media sources.

Some generic insecticides are formulated or sold by numerous pesticide formulators and distributors. However, names and formulations of these generic insecticides are diverse, so their inclusion in this chapter is limited. The most commonly available trade name and formulation of each insecticide are included in this chapter. This practice does not represent discrimination against other trade names and formulations of the same product. Producers are advised to discuss the availability of generic products with an agricultural supplier.

Insecticides suggested for use in field and forage crops are listed in Tables 1 to 7. Use rates and placement and timing of applications, as well as supportive comments, also are provided in the tables.

Directions for use, precautionary statements, and environmental and health hazards associated with insecticides have become increasingly complex and detailed, and such information changes frequently. Consequently, we have not provided this type of information in this chapter. However, it is important that you obtain the most current information about insecticides either from the manufacturers or from comprehensive publications. The *Crop Protection Handbook*, published by Meister Media Worldwide, Willoughby, Ohio, is an excellent reference for detailed and up-to-date information about all farm chemicals, including insecticides. The *Crop Protection Reference*, published by Vane Publishing Corporation, Lenexa, Kansas, is another comprehensive publication that contains current labels for most registered pesticides. Information from this publication is also available on the Web at http://www.greenbook.net. Labels of pesticides available from many companies also can be accessed from the home page of Crop Data Management Systems, Inc., http://www.cdms.net.

Transgenic corn hybrids modified by insertion of genes from the soil bacterium *Bacillus thuringiensis* that express crystalline proteins toxic to specific insects were commercialized for the first time in the mid-1990s. These corn hybrids are commonly referred to as Bt corn hybrids. The U.S. EPA has registered several products for control of a number of important insect pests of corn, including corn rootworms and

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The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.

Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.

several caterpillars—black cutworm, corn earworm, European corn borer, fall armyworm, southwestern corn borer, and western bean cutworm. Currently, there are three "families" of Bt corn products—Agrisure (Syngenta Seeds Inc.), Herculex (Dow AgroSciences LLC and Pioneer Hi-Bred International, Inc.), and YieldGard (Monsanto Company). All three families include transgenic Bt corn hybrids that control corn rootworms and caterpillars, either individually or in combination (that is, hybrids with "stacked" traits).

Because so many corn hybrids with transgenic traits (including genetic traits for herbicide tolerance or resistance) will be available for planting in 2008, a comprehensive list of these products is not included in this chapter. Individuals interested in learning more about transgenic corn hybrids are encouraged to contact one or more of the aforementioned seed companies. We strongly encourage corn growers who plant transgenic Bt corn hybrids for management of insect pests to comply with the insect-resistance-management (IRM) guidelines associated with all Bt corn products. In general, the IRM requirements, which are mandated by the U.S. EPA, include, but are not limited to, planting a non-Bt corn refuge on a minimum of 20 percent of the corn acres on a farm. For a practical and thorough explanation of the IRM requirements associated with transgenic Bt corn, visit the National Corn Growers Association (NCGA) Web site at http://www.ncga.com.

Additional Resources for Information About Insect Pests of Field and Forage Crops

The information provided in this chapter is intended primarily for individuals who make insect-control decisions during the growing season, which usually means application of an insecticide after scouting indicates the density of an insect has reached or exceeded an economic threshold. The guidelines in this chapter are complemented by many other resources that provide more detailed information about insects and their management.

In past volumes of this handbook, we provided considerable information about key insect pests of corn and soybean—biology, scouting procedures, management guidelines. However, many of these aspects of insect management are dynamic, often changing within a given growing season. This type of information is more suitable for dissemination over the Internet, allowing for revisions and updates. You can access this information from the University of Illinois IPM Web site, http://www.ipm.uiuc.edu. During the growing season, time-sensitive information about pest management and crop development is published weekly or more frequently in *the Bulletin* on the Web, http://www.ipm.uiuc.edu/bulletin.

Descriptions and life cycles of the major pests, scouting procedures, and nonchemical control tactics also are important for development of a completely integrated insect management program. More detailed discussions of scouting procedures and economic thresholds are published in the *Field Crop Scouting Manual* (University of Illinois) and in *Corn Insect Pests—A Diagnostic Guide* (University of Missouri and University of Illinois). Both publications include color photographs and discussions of life cycles. The *Field Crop Scouting Manual* is available in both print and CD format, and *Corn Insect Pests—A Diagnostic Guide* can be viewed on the Web at http://www.ipm.uiuc.edu/pubs/cip.pdf. More information about nonchemical management tactics and detailed information about the key insect pests of alfalfa, corn, soybean, and wheat are discussed in the *Field Crop Scouting Manual*.

Information about University of Illinois publications is available from your nearest Extension office or from Information Technology and Communication Services, Marketing and Distribution, 1917 S. Wright St., Champaign, IL 61820; (217)333-2007 or (800)345-6087; or online at https://PubsPlus.uiuc.edu/.

Recommended Web Resources

The Internet provides access to a multitude of informational sites that focus on management of pests. Following are a few relevant Web sites that provide very useful and timely information:

http://www.ipm.uiuc.edu/
University of Illinois IPM site

http://www.ipm.uiuc.edu/bulletin
the Bulletin. Pest management information throughout the growing season.

http://www.greenbook.net
Excellent site for current pesticide labels and material safety data sheets

http://www.cdms.net
An excellent index of chemical companies involved in agriculture, with links to companies' Web sites.

Land-grant universities in the north-central states issue weekly newsletters during the growing season with some focus on insect pests of field and forage crops, as well as on plant diseases and weeds. Following are the Web addresses for the newsletters published in other north-central states.

Indiana (Purdue University):
http://www.entm/purdue.edu/entomology/ext/ext_newsletters.html

Iowa State University:
http://www.ipm.iastate.edu/ipm/icm

Kansas State University:
http://www.oznet.ksu.edu/entomology/extension/KIN/KIN_current.htm

Kentucky, University of:
http://www.uky.edu/Ag/kpn/kpnhome.htm

Michigan State University:
http://www.ipm.msu.edu/field-cat.htm

Minnesota, University of:
http://www.extension.umn.edu/CropEnews

Missouri, University of:
http://ipm.missouri.edu/ipcm

Nebraska, University of:
http://cropwatch.unl.edu

North Dakota State University:
http://www.ag.ndsu.nodak.edu/aginfo/entomology/ndsucpr

Ohio State University:
http://corn.osu.edu

Wisconsin, University of:
http://ipcm.wisc.edu/wcm

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Table 1. Insecticides for field corn

Insect	Insecticide[a]	Amount of product[a] per acre or per 1,000 ft row (where indicated)	Placement	Timing of application, comments[b]
Armyworm	*Ambush 25W	6.4 to 12.8 oz	Broadcast	*Seedling corn:* Control may be justified when 25% of the plants are being damaged. *After pollen shed:* Control may be justified when armyworms are eating leaves above ear level.
	*Asana XL	5.8 to 9.6 oz		
	*Capture 2EC	2.1 to 6.4 oz		
	*Cobalt	13 to 26 oz		
	*Hero	4 to 10.3 oz		
	Intrepid 2F	4 to 8 oz		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	3.2 to 4 oz		
	*Penncap-M	2 to 3 pt		
	*Pounce 3.2EC	4 to 8 oz		
	Tracer	1 to 3 oz		
	*Warrior	2.56 to 3.84 oz		
Billbugs	*Cobalt	38 to 42 oz	Spray at base of plant or over row	Apply as a postemergence rescue treatment. Use only ground equipment, and apply 20 to 40 gallons of finished spray per acre.
	*Lorsban-4E	2 pt		
Chinch bug	*Asana XL	5.8 to 9.6 oz	Spray at base of plant	Treat border rows at the start of migration from small grains. Use only ground equipment.
	*Baythroid XL	1.6 to 2.8 oz		
	*Capture 2EC	2.1 to 6.4 oz		
	*Cobalt	19 to 38 oz		
	*Hero	4 to 10.3 oz		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	3.2 to 4 oz		
	*Proaxis	3.84 oz		
	Sevin XLR Plus	1 to 2 qt		
	*Warrior	3.84 oz		
Corn earworm	*Ambush 25W	6.4 to 12.8 oz	Overall spray or directed toward ear zone	Treatment is usually justified only in seed-corn fields. Treatments are rarely effective for the control of earworms after worms enter ear tips.
	*Asana XL	5.8 to 9.6 oz		
	*Baythroid XL	1.6 to 2.8 oz		
	*Capture 2EC	2.1 to 6.4 oz		
	*Cobalt	19 to 38 oz		
	*Hero	4 to 10.3 oz		
	*Mustang Max	2.72 to 4 oz		
	*Pounce 3.2EC	4 to 8 oz		
	*Proaxis	1.92 to 3.2 oz		
	Tracer	2 to 3 oz		
	*Warrior	1.92 to 3.2 oz		
Corn leaf aphid	*Asana XL	5.8 to 9.6 oz	Broadcast	Apply during late whorl to early tassel when 50% of plants have light to moderate infestations (50 to 400 aphids per plant) and plants are under drought stress. If soil moisture is adequate, treatment may be warranted if there are more than 400 aphids per plant. Do not apply dimethoate to corn during the pollen-shed period.
	*Capture 2EC	2.1 to 6.4 oz		
	*Cobalt	13 to 26 oz		
	Dimethoate 4EC	⅔ to 1 pt		
	*Hero	4 to 10.3 oz		
	*Lorsban-4E	1 to 2 pt		
	*Penncap-M	2 to 3 pt		

Table 1. Insecticides for field corn (cont.)

Insect	Insecticide[a]	Amount of product[a] per acre or per 1,000 ft row (where indicated)	Placement	Timing of application, comments[b]
Corn rootworm adults	*Ambush 25W	6.4 to 12.8 oz	Overall spray or directed toward ear zone	To protect pollination, treat if there are 5 or more beetles per plant, pollination is not complete, and silk clipping is observed.
	*Asana XL	5.8 to 9.6 oz		
	*Baythroid XL	1.6 to 2.8 oz		
	*Capture 2EC	2.1 to 6.4 oz		
	*Cobalt	13 to 26 oz		
	*Hero	4 to 10.3 oz		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	2.72 to 4 oz		
	*Penncap-M	1 to 2 pt		
	*Pounce 3.2EC	4 to 8 oz		
	*Proaxis	2.56 to 3.84 oz		
	Sevin XLR Plus	1 to 2 qt		
	*Warrior	2.56 to 3.84 oz		
Corn rootworm larvae	*Aztec 2.1%G	6.7 oz/1,000 ft row	Band,[c] furrow	At planting. To minimize potential adverse effects to wildlife, incorporate insecticide granules or apply the insecticide in-furrow (if labeled) and shut off insecticide units in turn rows.
	*Aztec 4.67G[d]	3 oz/1,000 ft row	Band,[c] furrow	
	*Capture 2EC	0.3 oz/1,000 ft row	Band[c]	
	*Counter15G[d]	8 oz/1,000 ft row	Band,[c] furrow	
	*Force 3G[d]	4 to 5 oz/1,000 ft row	Band,[c] furrow	
	*Force CS	0.46 to 0.57 oz/1,000 ft row	Band,[c] furrow	
	*Fortress 2.5G	7.5 to 9 oz/1,000 ft row	Furrow	
	*Fortress 5G[d]	3 to 4.5 oz/1,000 ft row	Furrow	
	*Lorsban-4E	2.4 fl oz/1,000 ft row	Band[b]	
	Lorsban 15G[d]	8 oz/1,000 ft row	Band[b]	
	Poncho 1250	See product label.	On seed	Select hybrids treated with Poncho 1250.
Cutworms[e]	*Ambush 25W	6.4 to 12.8 oz	Broadcast	Apply as a postemergence rescue treatment when 3 to 5% or more of the plants are cut and larvae are present.
	*Asana XL	5.8 to 9.6 oz		
	*Baythroid XL	0.8 to 1.6 oz		
	*Capture 2EC	2.1 to 6.4 oz		
	*Cobalt	13 to 26 oz		
	*Hero	2.6 to 6.1 oz		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	1.28 to 2.8 oz		
	*Pounce 3.2EC	4 to 8 oz		
	*Proaxis	1.92 to 3.2 oz		
	*Warrior	1.92 to 3.2 oz		
European corn borer, first generation *(continues)*	*Ambush 25W	6.4 to 12.8 oz	Broadcast	Use "Management Worksheet for First-Generation European Corn Borer" to aid in decision making (http://www.ipm.uiuc.edu/decision/corn_borer_first.html).
	Bacillus thuringiensis	See product label.	See product label.	
	*Baythroid XL	1.6 to 2.8 oz	Broadcast	
	*Capture 2EC	2.1 to 6.4 oz	Broadcast	
	*Cobalt	26 to 38 oz	Broadcast	
	*Hero	4 to 10.3 oz	Broadcast	
	Intrepid 2F	4 to 8 oz	Broadcast	
	*Lorsban-4E	1½ to 2 pt	Broadcast	
	Lorsban 15G	3.5 to 8 oz/1,000 ft row	Over whorls	

Table 1. Insecticides for field corn (cont.)

Insect	Insecticide[a]	Amount of product[a] per acre or per 1,000 ft row (where indicated)	Placement	Timing of application, comments[b]
European corn borer, first generation (cont.)	Lorsban 15G	5 to 6.5 lb	Broadcast	
	*Mustang Max	2.72 to 4 oz	Broadcast	
	*Penncap-M	2 pt	Over whorls	
	*Penncap-M	3 to 4 pt	Broadcast	
	*Pounce 1.5G	5 to 10 lb	Over whorls	
	*Pounce 1.5G	6.7 to 13.3 lb	Broadcast	
	*Pounce 3.2EC	4 to 8 oz	Broadcast	
	*Proaxis	2.56 to 3.84 oz	Broadcast	
	Tracer	1 to 3 oz	Broadcast	
	*Warrior	2.56 to 3.84 oz	Broadcast	
European corn borer, second generation	*Ambush 25W	6.4 to 12.8 oz	Broadcast	Use "Management Worksheet for Second-Generation European Corn Borer" to aid in decision making (http://www.ipm.uiuc.edu/decision/corn_borer_second.html).
	*Baythroid XL	1.6 to 2.8 oz		
	*Capture 2EC	2.1 to 6.4 oz		
	*Cobalt	26 to 38 oz		
	*Hero	4 to 10.3 oz		
	Intrepid 2F	4 to 8 oz		
	*Lorsban-4E	1½ to 2 pt		
	Lorsban 15G	6.5 lb		
	*Mustang Max	2.72 to 4 oz		
	*Penncap-M	2 to 4 pt		
	*Pounce 1.5G	6.7 to 13.3 lb		
	*Pounce 3.2EC	4 to 8 oz		
	*Proaxis	2.56 to 3.84 oz		
	Tracer	1 to 3 oz		
	*Warrior	2.56 to 3.84 oz		
Fall armyworm	*Capture 2EC	2.1 to 6.4 oz	Broadcast	Treat when 75% of plants have whorl damage and if worms are present. Ground sprays directed over the row are more effective than broadcast sprays. Treatments to control worms in ear tips are not effective.
	*Cobalt	13 to 26 oz		
	*Hero	4 to 10.3 oz		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	3.2 to 4 oz		
	*Pounce 3.2EC	4 to 8 oz		
	Tracer	1 to 3 oz		
	*Warrior	2.56 to 3.84 oz		
Flea beetles	*Ambush 25W	6.4 to 12.8 oz	Over row as spray	Treat when leaves on seedling plants are severely damaged and plants are being killed. For Lorsban, use only ground equipment and apply 20 to 40 gallons of finished spray per acre.
	*Asana XL	5.8 to 9.6 oz		
	*Baythroid XL	0.8 to 1.6 oz		
	*Capture 2EC	2.1 to 6.4 oz		
	*Cobalt	13 to 26 oz		
	*Hero	2.6 to 6.1 oz		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	2.72 to 4 oz		
	*Penncap-M	2 to 3 pt		
	*Pounce 3.2EC	4 to 8 oz		
	*Proaxis	2.56 to 3.84 oz		
	Sevin XLR Plus	1 to 2 qt		
	*Warrior	2.56 to 3.84 oz		

Table 1. Insecticides for field corn (cont.)

Insect	Insecticide[a]	Amount of product[a] per acre or per 1,000 ft row (where indicated)	Placement	Timing of application, comments[b]
Grasshoppers	*Asana XL	5.8 to 9.6 oz		Treatment may be warranted when there are 7 or more grasshoppers per square yard. After pollen shed, control may be justified when grasshoppers are feeding on leaves above ear level. Do not apply dimethoate to corn during the pollen-shed period.
	*Baythroid XL	2.1 to 2.8 oz		
	*Capture 2EC	2.1 to 6.4 oz	Broadcast	
	*Cobalt	7 to 13 oz		
	Dimethoate 4EC	1 pt		
	*Hero	2.6 to 6.1 oz		
	*Lorsban-4E	½ to 1 pt		
	*Mustang Max	2.72 to 4 oz		
	*Penncap-M	2 to 3 pt		
	*Proaxis	2.56 to 3.84 oz		
	Sevin XLR Plus	½ to 1½ qt		
	*Warrior	2.56 to 3.84 oz		
Hop vine borer	*Cobalt	19 to 38 oz	Broadcast	Apply postemergence sprays when young larvae are moving from weed hosts into corn.
	*Hero	2.6 to 6.1 oz		
	*Mustang Max	2.72 to 4 oz		
	*Pounce 3.2EC	4 to 8 oz		
	*Proaxis	2.56 to 3.84 oz		
	*Warrior	2.56 to 3.84 oz		
Japanese beetle (adults)	*Asana XL	5.8 to 9.6 oz	Broadcast	Treat during tasseling and silking if there are 3 or more beetles per ear and pollination is not complete.
	*Baythroid XL	1.6 to 2.8 oz		
	*Capture 2EC	2.1 to 6.4 oz		
	*Cobalt	38 to 42 oz		
	*Hero	4 to 10.3 oz		
	*Mustang Max	2.72 to 4 oz		
	*Penncap-M	2 to 4 pt		
	*Proaxis	2.56 to 3.84 oz		
	Sevin XLR Plus	1 to 2 qt		
	*Warrior	2.56 to 3.84 oz		
Picnic, sap beetles	*Capture 2EC	2.1 to 6.4 oz	Broadcast	Treatment is justified only in seed-corn fields when beetles are causing significant injury to ear tips.
	*Cobalt	19 to 38 oz		
	*Hero	4 to 10.3 oz		
	*Mustang Max	2.72 to 4 oz		
	*Penncap-M	2 to 3 pt		
	*Proaxis	2.56 to 3.84 oz		
	Sevin XLR Plus	1 to 2 qt		
	*Warrior	2.56 to 3.84 oz		
Seedcorn maggot	Cruiser	See product label.	On seed	Use formulations that are prepared as seed treaters, or select hybrids treated with Cruiser or Poncho. Seed treatments should be considered for fields that do not receive a soil insecticide at planting. See label for proper disposal of treated seeds.
	diazinon + lindane	See product label.	On seed	
	imidacloprid	See product label.	On seed	
	permethrin	See product label.	On seed	
	Poncho	See product label.	On seed	

Table 1. Insecticides for field corn (cont.)

Insect	Insecticide[a]	Amount of product[a] per acre or per 1,000 ft row (where indicated)	Placement	Timing of application, comments[b]
Southern corn leaf beetle	*Baythroid XL	1.6 to 2.8 oz	Broadcast	Apply as a postemergence rescue treatment.
	*Capture 2EC	2.1 to 6.4 oz		
	*Cobalt	13 to 26 oz		
	*Hero	4 to 10.3 oz		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	2.72 to 4 oz		
	*Warrior	3.84 oz		
Southwestern corn borer, second generation	*Ambush 25W	6.4 to 12.8 oz	Broadcast	Treatment may be warranted when 20 to 25% of the plants are infested with eggs or newly hatched larvae.
	*Asana XL	5.8 to 9.6 oz		
	*Baythroid XL	1.6 to 2.8 oz		
	*Capture 2EC	2.1 to 6.4 oz		
	*Cobalt	19 to 38 oz		
	*Hero	4 to 10.3 oz		
	Intrepid 2F	4 to 8 oz		
	*Lorsban-4E	1½ to 2 pt		
	Lorsban 15G	6.5 lb		
	*Mustang Max	2.72 to 4 oz		
	*Penncap-M	2 to 4 pt		
	*Pounce 1.5G	6.7 to 13.3 lb		
	*Pounce 3.2EC	4 to 8 oz		
	*Proaxis	2.56 to 3.84 oz		
	Tracer	2 to 3 oz		
	*Warrior	2.56 to 3.84 oz		
Spider mites	*Capture 2EC	5.12 to 6.4 oz	Broadcast	Begin control if the majority of plants are infested with mites severely enough to cause some yellowing or browning of the lower leaves before dent stage. Do not apply dimethoate to corn during the pollen-shed period.
	Dimethoate 4EC	⅔ to 1 pt		
	*Hero	10.3 oz		
Stalk borer	*Ambush 25W	6.4 to 12.8 oz	Broadcast	Apply postemergence sprays when young larvae are moving from weed hosts to corn. See labels for more specific instructions about effective control.
	*Asana XL	5.8 to 9.6 oz		
	*Baythroid XL	1.6 to 2.8 oz		
	*Capture 2EC	2.1 to 6.4 oz		
	*Cobalt	38 to 42 oz		
	*Hero	2.6 to 6.1 oz		
	*Lorsban-4E	2 pt		
	*Mustang Max	2.72 to 4 oz		
	*Pounce 3.2EC	4 to 8 oz		
	*Proaxis	2.56 to 3.84 oz		
	*Warrior	2.56 to 3.84 oz		

Table 1. Insecticides for field corn (cont.)

Insect	Insecticide[a]	Amount of product[a] per acre or per 1,000 ft row (where indicated)	Placement	Timing of application, comments[b]
Stink bugs	*Baythroid XL	1.6 to 2.8 oz	Broadcast	Apply as a postemergence rescue treatment.
	*Capture 2EC	2.1 to 6.4 oz		
	*Cobalt	38 to 42 oz		
	*Hero	4 to 10.3 oz		
	*Mustang Max	2.72 to 4 oz		
	*Penncap-M	1 to 3 pt		
	*Proaxis	2.56 to 3.84 oz		
	*Warrior	2.56 to 3.84 oz		
Webworms	*Baythroid XL	1.6 to 2.8 oz	Broadcast	For Lorsban, shallow incorporation using a rotary hoe or other suitable equipment immediately before or soon after treatment is necessary.
	*Capture 2EC	2.1 to 6.4 oz		
	*Cobalt	13 to 26 oz		
	*Hero	4 to 10.3 oz		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	2.72 to 4 oz		
	*Pounce 3.2EC	4 to 8 oz		
	*Proaxis	2.56 to 3.84 oz		
	*Warrior	2.56 to 3.84 oz		
Western bean cutworm	*Asana XL	2.9 to 5.8 oz	Broadcast	Treatment may be warranted when 8% of plants have egg masses and/or small larvae.
	*Baythroid XL	1.6 to 2.8 oz		
	*Capture 2EC	2.1 to 6.4 oz		
	*Cobalt	13 to 26 oz		
	*Hero	2.6 to 6.1 oz		
	Intrepid 2F	4 to 8 oz		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	1.76 to 4 oz		
	*Penncap-M	2 to 4 pt		
	*Pounce 3.2EC	2 to 4 oz		
	*Proaxis	1.92 to 3.20 oz		
	Sevin XLR Plus	2 qt		
	Tracer	2 to 3 oz		
	*Warrior	1.92 to 3.20 oz		
White grubs *(continues)*	*Aztec 2.1%G	6.7 oz/1,000 ft row	Band,[c] furrow	Treat if crop history and previous crop losses can be directly linked to a repeated history of grub problems. To minimize potential adverse effects to wildlife, incorporate insecticide granules or apply the insecticide in-furrow (if labeled) and shut off insecticide units in turn rows.
	*Aztec 4.67G[d]	3 oz/1,000 ft row	Band,[c] furrow	
	*Capture 2EC	0.15 to 0.3 oz/1,000 ft row	Band[c]	
	*Capture 2EC	3 to 4 oz	BC-PPI[f]	
	*Counter 15G[d]	8 oz/1,000 ft row	Band,[c] furrow	
	*Force 3G[d]	4 to 5 oz/1,000 ft row	Furrow	
	*Force CS	0.46 to 0.57 oz/1,000 ft row	Furrow	
	*Fortress 2.5G	6 to 7.5 oz/1,000 ft row	Furrow	
	*Fortress 5G[d]	3 to 3.75 oz/1,000 ft row	Furrow	
	*Lorsban-4E	4 pt	BC-PPI[f]	
	Lorsban 15G[d]	8 oz/1,000 ft row	Band,[c] furrow	

Table 1. Insecticides for field corn (cont.)

Insect	Insecticide[a]	Amount of product[a] per acre or per 1,000 ft row (where indicated)	Placement	Timing of application, comments[b]
White grubs (cont.)	*Proaxis	0.66 oz/1,000 ft row	Band,[c] furrow	
	*Regent 4SC	0.24 oz/1,000 ft row	Furrow	
	*Warrior	0.66 oz/1,000 ft row	Band,[c] furrow	
	Cruiser	See product label.	On seed	Select hybrids treated with Cruiser or Poncho.
	Poncho	See product label.	On seed	
Wireworms	*Aztec 2.1%G	6.7 oz/1,000 ft row	Band,[c] furrow	Treat at planting if crop history or bait stations or both indicate a potential for wireworm damage. To minimize potential adverse effects to wildlife, incorporate insecticide granules or apply the insecticide in-furrow (if labeled) and shut off insecticide units in turn rows.
	*Aztec 4.67G[d]	3 oz/1,000 ft row	Band,[c] furrow	
	*Capture 2EC	0.15 to 0.3 oz/1,000 ft row	Band[c]	
	*Capture 2EC	3 to 4 oz	BC-PPI[f]	
	*Counter 15G[d]	8 oz/1,000 ft row	Band,[c] furrow	
	*Force 3G[d]	4 to 5 oz/1,000 ft row	Furrow	
	*Force CS	0.46 to 0.57 oz/1,000 ft row	Furrow	
	*Fortress 2.5G	6 to 7.5 oz/1,000 ft row	Furrow	
	*Fortress 5G[d]	3 to 3.75 oz/1,000 ft row	Furrow	
	*Lorsban-4E	4 pt	BC-PPI[f]	
	Lorsban 15G	8 oz/1,000 ft row	Furrow	
	*Pounce 1.5G	8 oz/1,000 ft row	Furrow	
	*Pounce 3.2EC	0.3 oz/1,000 ft row	Furrow	
	*Regent 4SC	0.24 oz/1,000 ft row	Furrow	
	*Warrior	0.66 oz/1,000 ft row	Band,[c] furrow	
	Cruiser	See product label.	On seed	Use formulations that are prepared as seed treaters, or select hybrids treated with Cruiser or Poncho. See label for proper disposal of treated seeds.
	diazinon + lindane	See product label.	On seed	
	imidacloprid	See product label.	On seed	
	permethrin	See product label.	On seed	
	Poncho	See product label.	On seed	

*Use restricted to certified applicators.

[a]The formulation of the product most commonly used in Illinois is listed. If you use another formulation, *read the label* to determine the amount of product per acre. Also, read the product label for precautions and restrictions.

[b]The economic thresholds indicated are nominal (based on experience) or simple (based on research regarding the average response of the crop to insect injury). Dynamic thresholds that vary with cost of control, expected yield, crop value, and other variables have been developed for some insect pests. These dynamic thesholds often are published in newsletters during the growing season (refer to Web addresses on page 2.)

[c]Band = band over the row, or T-band over an open seed furrow. Refer to product label for specific information and band width.

[d]Aztec 4.67G and Fortress 5G are available only in the SmartBox closed handling and application system. Counter 15G, Force 3G, and Lorsban 15G also are available in the SmartBox closed handling and application system.

[e]We recommend that cutworms be controlled with insecticides only if densities of cutworms exceed established economic thresholds.

[f]BC-PPI = broadcast–preplant incorporated.

Table 2. Insecticides for soybean

Spraying blossoming soybean can be extremely hazardous to bees. Coordinate with local beekeepers before applying sprays. Beekeepers' names and colony locations may be obtained from your local Extension office.

Insect	Insecticide[a]	Amount of product per acre[a]	Placement	Timing of application, comments[b]
Bean leaf beetle	*Ambush 25W	3.2 to 6.4 oz	On foliage	*Seedlings:* In fields with a history of bean pod mottle virus transmitted by bean leaf beetles, preventive treatments may be justified. The seed treatments Cruiser and Gaucho control bean leaf beetles early in the season. In areas without a history of bean pod mottle virus, densities of 16 beetles per foot of row in the early seedling state or 39 per foot of row at stage V2+ are necessary for economic damage. *Before bloom:* Treat when defoliation reaches 30% and there are 5 or more beetles per foot of row. *Bloom to pod fill:* Treat when defoliation reaches 20%. *Seed maturation:* Treat when 5 to 10% of the pods are damaged, the leaves are green, and there are 10 or more beetles per foot of row.
	*Asana XL	5.8 to 9.6 oz		
	*Baythroid XL	0.8 to 2.8 oz		
	*Cobalt	19 to 38 oz		
	Dimethoate 4EC	1 pt		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	2.8 to 4 oz		
	Orthene 90S	0.83 to 1.1 lb		
	*Penncap-M	2 to 3 pt		
	*Pounce 3.2EC	2 to 4 oz		
	*Proaxis	1.92 to 3.2 oz		
	Sevin XLR Plus	½ to 1 qt		
	*Warrior	1.92 to 3.2 oz		
Blister beetles	*Baythroid XL	1.6 to 2.8 oz	On foliage	Treat when defoliation reaches 30% before bloom and 20% between bloom and pod fill.
	*Cobalt	13 to 26 oz		
	*Mustang Max	2.8 to 4 oz		
	*Proaxis	3.2 to 3.84 oz		
	Sevin XLR Plus	½ to 1 qt		
	*Warrior	3.2 to 3.84 oz		
Corn earworm	*Ambush 25W	6.4 to 12.8 oz	On foliage	Treat when defoliation reaches 30% before bloom and 20% between bloom and pod fill, or when 5 to 10% of the pods are damaged.
	*Asana XL	5.8 to 9.6 oz		
	*Baythroid XL	1.6 to 2.8 oz		
	*Cobalt	19 to 38 oz		
	*Mustang Max	2.8 to 4 oz		
	*Pounce 3.2EC	4 to 8 oz		
	*Proaxis	1.92 to 3.2 oz		
	Tracer	1.5 to 2 oz		
	*Warrior	1.92 to 3.2 oz		
Cutworms	*Asana XL	5.8 to 9.6 oz	Broadcast	Scout as plants are emerging. Treat if 20% of plants are cut, stand has gaps of 1 foot or more, and cutworms are present.
	*Baythroid XL	0.8 to 1.6 oz		
	*Cobalt	13 to 26 oz		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	1.28 to 4 oz		
	*Pounce 3.2EC	2 to 4 oz		
	*Proaxis	1.92 to 3.2 oz		
	*Warrior	1.92 to 3.2 oz		

Table 2. Insecticides for soybean (cont.)

Insect	Insecticide[a]	Amount of product per acre[a]	Placement	Timing of application, comments[b]
Grasshoppers	*Asana XL	5.8 to 9.6 oz	On foliage	Treat when migration into fields begins and defoliation or pod feeding reaches economic levels; when defoliation reaches 30% before bloom and 20% between bloom and pod fill; when 5 to 10% of the pods are damaged.
	*Baythroid XL	2 to 2.8 oz		
	*Cobalt	7 to 13 oz		
	Dimethoate 4EC	1 pt		
	*Lorsban-4E	½ to 1 pt		
	*Mustang Max	3.2 to 4 oz		
	Orthene 90S	0.28 to 0.56 lb		
	*Penncap-M	2 to 3 pt		
	*Proaxis	3.2 to 3.84 oz		
	Sevin XLR Plus	½ to 1½ qt		
	*Warrior	3.2 to 3.84 oz		
Green cloverworm	*Ambush 25W	3.2 to 6.4 oz	On foliage	Treat when defoliation occurs during blooming, pod set, and pod fill. Usually requires 12 or more half-grown worms per foot of row and 20% defoliation to justify treatment.
	*Asana XL	2.9 to 5.8 oz		
	*Baythroid XL	0.8 to 1.6 oz		
	*Cobalt	7 to 13 oz		
	*Lorsban-4E	½ to 1 pt		
	*Mustang Max	2.8 to 4 oz		
	Orthene 90S	0.83 to 1.1 lb		
	*Penncap-M	2 to 3 pt		
	*Pounce 3.2EC	2 to 4 oz		
	*Proaxis	1.92 to 3.2 oz		
	Sevin XLR Plus	½ to 1 qt		
	Tracer	1 to 2 oz		
	*Warrior	1.92 to 3.2 oz		
Japanese beetle adults	*Ambush 25W	6.4 to 12.8 oz	On foliage	Treat when defoliation reaches 30% before bloom and 20% between bloom and pod fill.
	*Asana XL	5.8 to 9.6 oz		
	*Baythroid XL	1.6 to 2.8 oz		
	*Cobalt	19 to 38 oz		
	*Mustang Max	2.8 to 4 oz		
	*Penncap-M	2 to 3 pt		
	*Pounce 3.2EC	2 to 4 oz		
	*Proaxis	3.2 to 3.84 oz		
	Sevin XLR Plus	½ to 1 qt		
	*Warrior	3.2 to 3.84 oz		
Mexican bean beetle	*Ambush 25W	3.2 to 6.4 oz	On foliage	Treat when defoliation reaches 30% before bloom and 20% between bloom and pod fill.
	*Asana XL	2.9 to 5.8 oz		
	*Baythroid XL	1.6 to 2.8 oz		
	*Cobalt	19 to 38 oz		
	Dimethoate 4EC	1 pt		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	2.8 to 4 oz		
	Orthene 90S	0.83 to 1.1 lb		
	*Penncap-M	2 to 3 pt		
	*Pounce 3.2EC	2 to 4 oz		
	*Proaxis	1.92 to 3.2 oz		
	Sevin XLR Plus	½ to 1 qt		
	*Warrior	1.92 to 3.2 oz		

Table 2. Insecticides for soybean (cont.)

Insect	Insecticide[a]	Amount of product per acre[a]	Placement	Timing of application, comments[b]
Potato leafhopper	*Ambush 25W	3.2 to 6.4 oz	On foliage	Treat when leafhoppers are numerous and the edges of the leaves appear burned. For susceptible varieties, control in blooming soybeans may be warranted when 6 or more leafhoppers are found per plant. During early seed formation, control may be warranted if 13 or more leafhoppers are found per plant.
	*Asana XL	2.9 to 5.8 oz		
	*Baythroid XL	0.8 to 1.6 oz		
	*Cobalt	19 to 38 oz		
	Dimethoate 4EC	1 pt		
	*Mustang Max	2.8 to 4 oz		
	Orthene 90S	0.56 to 1.1 lb		
	*Penncap-M	2 to 3 pt		
	*Pounce 3.2EC	2 to 4 oz		
	*Proaxis	1.92 to 3.2 oz		
	Sevin XLR Plus	1 qt		
	*Warrior	1.92 to 3.2 oz		
Seedcorn maggot	Cruiser	See product label.	On seed	Use formulations that are prepared as seed treaters, or select varieties treated with Cruiser or Gaucho. See label for proper disposal of treated seeds.
	Gaucho	See product label.	On seed	
	permethrin	See product label.	On seed	
Soybean aphid	*Asana XL	5.8 to 9.6 oz	On foliage	Treatment may be warranted if there are 250 or more aphids per plant at the R1 through R5 stages of development, 80% of the plants are infested, and natural enemies are not suppressing the aphid population.
	*Baythroid XL	2 to 2.8 oz		
	*Cobalt	13 to 26 oz		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	2.8 to 4 oz		
	Orthene 90S	0.83 to 1.1 lb		
	*Penncap-M	1 to 3 pt		
	*Pounce 3.2EC	4 to 8 oz		
	*Proaxis	1.92 to 3.2 oz		
	*Warrior	1.92 to 3.2 oz		
Soybean looper	*Ambush 25W	6.4 to 12.8 oz	On foliage	Treat when defoliation reaches 30% before bloom and 20% between bloom and pod fill.
	*Mustang Max	3.2 to 4 oz		
	*Penncap-M	2 to 3 pt		
	*Pounce 3.2EC	4 to 8 oz		
	Tracer	1 to 2 oz		
Spider mites	Dimethoate 4EC	1 pt	On foliage	Treat when 20 to 25% discoloration is noted before pod set, or 10 to 15% discoloration after pod set.
	*Lorsban-4E	1 to 2 pt		
Stink bugs	*Asana XL	5.8 to 9.6 oz	On foliage	Treat when adult bugs or large nymphs reach 1 per foot of row during pod fill.
	*Baythroid XL	1.6 to 2.8 oz		
	*Cobalt	19 to 38 oz		
	*Lorsban-4E	2 pt		
	*Mustang Max	3.2 to 4 oz		
	Orthene 90S	0.56 to 1.1 lb		
	*Penncap-M	1 to 3 pt		
	*Proaxis	3.2 to 3.84 oz		
	Sevin XLR Plus	1 to 1½ qt		
	*Warrior	3.2 to 3.84 oz		

Table 2. Insecticides for soybean (cont.)

Insect	Insecticide[a]	Amount of product per acre[a]	Placement	Timing of application, comments[b]
Thistle caterpillar	*Cobalt	13 to 26 oz	On foliage	Treat when defoliation reaches 30% before bloom and 20% between bloom and pod fill.
	*Mustang Max	1.28 to 4 oz		
	*Pounce 3.2EC	2 to 4 oz		
	*Proaxis	1.92 to 3.2 oz		
	Sevin XLR Plus	1½ qt		
	*Warrior	1.92 to 3.2 oz		
Thrips	*Baythroid XL	0.8 to 1.6 oz	On foliage	Treat if seedlings are being seriously damaged and some plants are being killed.
	*Cobalt	19 to 38 oz		
	Orthene 90S	0.28 to 0.56 lb		
	*Penncap-M	2 to 3 pt		
	*Proaxis	1.92 to 3.2 oz		
	Sevin XLR Plus	1 qt		
	*Warrior	1.92 to 3.2 oz		
Woollybear caterpillars	*Ambush 25W	3.2 to 6.4 oz	On foliage	Treat when defoliation reaches 30% before bloom and 20% between bloom and pod fill.
	*Asana XL	2.9 to 5.8 oz		
	*Baythroid XL	1.6 to 2.8 oz		
	*Cobalt	13 to 26 oz		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	2.8 to 4 oz		
	*Pounce 3.2EC	2 to 4 oz		
	*Proaxis	1.92 to 3.2 oz		
	Sevin XLR Plus	1½ qt		
	Tracer	1.5 to 2 oz		
	*Warrior	1.92 to 3.2 oz		

*Use restricted to certified applicators.

[a]The formulation of the product most commonly used in Illinois is listed. If you use another formulation, *read the label* to determine the amount of product per acre. Also, read the product label for precautions and restrictions.

[b]The economic thresholds indicated are nominal (based on experience) or simple (based on research regarding the average response of the crop to insect injury). Dynamic thresholds that vary with cost of control, expected yield, crop value, and other variables have been developed for some insect pests. These dynamic thesholds often are published in newsletters during the growing season (refer to Web addresses on page 2.)

Table 3. Insecticides for alfalfa

Spraying blossoming alfalfa can be extremely hazardous to bees. Coordinate with local beekeepers before applying sprays. Beekeepers' names and colony locations may be obtained from your local Extension office.

Insect	Insecticide[a]	Amount of product per acre[a]	Placement	Timing of application, comments[b]
Alfalfa blotch leafminer	*Baythroid XL	2 to 2.8 oz	On foliage	Specific economic thresholds have not been established in the Midwest. Treatment may be warranted if injury is severe.
	*Cobalt	19 to 38 oz		
	*Lorsban-4E	1 to 2 pt		
	*Proaxis	3.84 oz		
	Sevin XLR Plus	1 to 1½ qt		
	*Warrior	3.84 oz		
Alfalfa caterpillar	*Ambush 25W	3.2 to 12.8 oz	On foliage	Treat when damage to foliage is obvious and there are at least 10 nonparasitized larvae per sweep.
	*Baythroid XL	1.6 to 2.8 oz		
	*Cobalt	13 to 26 oz		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	2.24 to 4 oz		
	*Pounce 3.2EC	2 to 8 oz		
	*Proaxis	1.92 to 3.2 oz		
	Sevin XLR Plus	1 qt		
	*Warrior	1.92 to 3.2 oz		
Alfalfa weevil	*Ambush 25W	12.8 oz	On foliage	When 25 to 50% of tips are being skeletonized and there are 3 or more larvae per stem, treat immediately. Do not apply sprays during bloom. Instead, cut and remove the hay. Control also may be warranted after a cutting when larvae and adults are feeding on more than 50% of the crowns and regrowth is prevented for 3 to 6 days.
	*Baythroid XL	1.6 to 2.8 oz		
	*Cobalt	19 to 38 oz		
	Imidan 70W	1 to 1⅓ lb		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	2.24 to 4 oz		
	*Pounce 3.2EC	4 to 8 oz		
	*Proaxis	2.56 to 3.84 oz		
	*Warrior	2.56 to 3.84 oz		
Blister beetles	*Cobalt	19 to 38 oz	On foliage	Although blister beetles rarely cause economic damage to alfalfa, their presence in hay could injure horses if the horses ingest the beetles.
	*Proaxis	2.56 to 3.84 oz		
	Sevin XLR Plus	½ to 1 qt		
	*Warrior	2.56 to 3.84 oz		
Cowpea aphid	*Cobalt	19 to 38 oz	On foliage, stems	No economic thresholds have been established for the cowpea aphid in alfalfa. The thresholds for the blue alfalfa aphid may suffice: plant height < 10 inches, 10 to 12 aphids per stem; plant height 10 inches or taller, 40 to 50 aphids per stem.
	Dimethoate 4EC	½ to 1 pt		
	*Lorsban-4E	1 to 2 pt		
	*Proaxis	2.56 to 3.84 oz		
	*Warrior	2.56 to 3.84 oz		
Cutworms	*Ambush 25W	3.2 to 12.8 oz	On seedlings	Control may be warranted when larvae reduce the stand of a new seeding or prevent regrowth after harvest.
	*Baythroid XL	0.8 to 1.6 oz		
	*Cobalt	13 to 26 oz		
	*Lorsban-4E	1 to 2 pt		
	*Mustang Max	2.24 to 4 oz		
	*Pounce 3.2EC	2 to 8 oz		
	*Proaxis	1.92 to 3.2 oz		
	*Warrior	1.92 to 3.2 oz		

Table 3. Insecticides for alfalfa (cont.)

Insect	Insecticide[a]	Amount of product per acre[a]	Placement	Timing of application, comments[b]
Fall armyworm	*Ambush 25W *Cobalt *Lorsban-4E *Mustang Max *Pounce 3.2EC *Proaxis *Warrior	3.2 to 12.8 oz 19 to 38 oz 1 to 2 pt 2.8 to 4 oz 2 to 8 oz 2.56 to 3.84 oz 2.56 to 3.84 oz	On seedlings	Control may be warranted when larvae reduce the stand of a new seeding, when there are 2 or more larvae per sweep, or when there are 1 to 2 half-grown larvae per square foot.
Grasshoppers	*Baythroid XL *Cobalt Dimethoate 4EC Imidan 70W *Lorsban-4E *Mustang Max *Proaxis Sevin XLR Plus *Warrior	2 to 2.8 oz 7 to 13 oz ½ to 1 pt 1 to 1⅓ lb ½ to 1 pt 2.8 to 4 oz 2.56 to 3.84 oz ½ to 1½ qt 2.56 to 3.84 oz	On foliage	Treat when grasshoppers are small, before damage is severe, and when there are 15 to 20 per square yard.
Meadow spittlebug	*Ambush 25W *Baythroid XL *Cobalt Imidan 70W *Lorsban-4E *Mustang Max *Pounce 3.2EC *Proaxis *Warrior	6.4 to 12.8 oz 0.8 to 1.6 oz 19 to 38 oz 1 to 1⅓ lb 1 to 2 pt 2.24 to 4 oz 4 to 8 oz 2.56 to 3.84 oz 2.56 to 3.84 oz	On foliage	Treat when spittle masses are found and nymphs average more than 1 per stem.
Plant bugs	*Ambush 25W *Baythroid XL *Cobalt Dimethoate 4EC *Lorsban-4E *Mustang Max *Pounce 3.2EC *Proaxis Sevin XLR Plus *Warrior	12.8 oz 1.6 to 2.8 oz 19 to 38 oz ½ to 1 pt 1 to 2 pt 2.8 to 4 oz 4 to 8 oz 2.56 to 3.84 oz 1 to 1½ qt 2.56 to 3.84 oz	On foliage	Treat when tip damage is obvious and nymphs and adults average 3 per sweep on alfalfa less than 3 inches tall, or 5 per sweep on alfalfa taller than 3 inches.
Potato leafhopper	*Ambush 25W *Baythroid XL *Cobalt Dimethoate 4EC Imidan 70W *Lorsban-4E *Mustang Max *Pounce 3.2EC *Proaxis Sevin XLR Plus *Warrior	3.2 to 12.8 oz 0.8 to 1.6 oz 7 to 13 oz ½ to 1 pt 1 to 1⅓ lb ½ to 1 pt 2.24 to 4 oz 4 to 8 oz 1.92 to 3.2 oz 1 qt 1.92 to 3.2 oz	On foliage	Treatment is justified at these combinations of alfalfa height and leafhopper numbers: Alfalfa height (inches) / Leafhoppers per sweep Under 3 — 0.2 3 to 6 — 0.5 6 to 12 — 1.0 12 or taller — 2.0

Table 3. Insecticides for alfalfa (cont.)

Insect	Insecticide[a]	Amount of product per acre[a]	Placement	Timing of application, comments[b]
Webworms	*Ambush 25W	3.2 to 12.8 oz	On seedlings or foliage	Control may be warranted when larvae reduce the stand of a new seeding or when heavy infestations result in copious webbing.
	*Baythroid XL	1.6 to 2.8 oz		
	*Cobalt	13 to 26 oz		
	*Mustang Max	2.24 to 4 oz		
	*Pounce 3.2EC	2 to 8 oz		
	*Proaxis	1.92 to 3.2 oz		
	Sevin XLR Plus	1 to 1½ qt		
	*Warrior	1.92 to 3.2 oz		

*Use restricted to certified applicators.
[a]The formulation of the product most commonly used in Illinois is listed. If you use another formulation, *read the label* to determine the amount of product per acre. Also, read the product label for precautions and restrictions.
[b]The economic thresholds indicated are nominal (based on experience) or simple (based on research regarding the average response of the crop to insect injury). dynamic thresholds that vary with cost of control, expected yield, crop value, and other variables have been developed for some insects pests. These dynamic thesholds often are published in newsletters during the growing season (refer to Web addresses on page 2.)

Table 4. Insecticides for grain sorghum

Insect	Insecticide[a]	Amount of product per acre[a]	Placement	Timing of application, comments[b]
Chinch bug	*Asana XL	5.8 to 9.6 oz	At plant base	Direct spray toward base of plant. Use only ground equipment.
	*Baythroid XL	2 to 2.8 oz		
	*Cobalt	13 to 38 oz		
	*Lorsban-4E[c]	1 to 2 pt		
	*Mustang Max	3.2 to 4 oz		
	*Proaxis	3.84 oz		
	Sevin XLR Plus	1 to 2 qt		
	*Warrior	3.84 oz		
Corn earworm (headworm)	*Asana XL	5.8 to 9.6 oz	Over row	Treat when there is an average of 2 or more larvae per head.
	*Baythroid XL	1.3 to 2.8 oz		
	*Cobalt	19 to 38 oz		
	*Mustang Max	1.76 to 4 oz		
	*Proaxis	2.56 to 3.84 oz		
	Tracer	1.5 to 3 oz		
	*Warrior	2.56 to 3.84 oz		
Corn leaf aphid	Dimethoate 4EC[c]	½ to 1 pt	Over row	Corn leaf aphids rarely cause economic damage unless populations are heavy and drought conditions exist.
	*Lorsban-4E[c]	½ to 1 pt		
Cutworms	*Asana XL	5.8 to 9.6 oz	Broadcast	Treat when seedling plants are being cut.
	*Baythroid XL	1 to 1.3 oz		
	*Cobalt	13 to 38 oz		
	*Lorsban-4E[c]	1 to 2 pt		
	*Mustang Max	1.28 to 4 oz		
	*Proaxis	1.92 to 2.56 oz		
	*Warrior	1.92 to 2.56 oz		

Table 4. Insecticides for grain sorghum (cont.)

Insect	Insecticide[a,b]	Amount of product per acre[a]	Placement	Timing of application, comments[b]
Fall armyworm	*Cobalt	13 to 38 oz	Over row	Treat when there is an average of 2 or more larvae per head. Leaf feeding or whorl damage seldom has an economic effect.
	*Lorsban-4E[c]	1 to 2 pt		
	*Mustang Max	1.76 to 4 oz		
	Tracer	1.5 to 3 oz		
Grasshoppers	*Baythroid XL	2 to 2.8 oz		Treatment may be warranted when there are 7 or more grasshoppers per square yard.
	*Cobalt	7 to 13 oz		
	Dimethoate 4EC[c]	1 pt		
	*Lorsban-4E[c]	½ to 1 pt		
	*Mustang Max	3.2 to 4 oz		
	*Proaxis	2.56 to 3.84 oz		
	Sevin XLR Plus	½ to 1½ qt		
	*Warrior	2.56 to 3.84 oz		
Greenbug	*Cobalt	13 to 38 oz	Over row	Treat when greenbug damage is sufficient to cause death of more than 2 normal-sized leaves before the hard-dough stage.
	Dimethoate 4EC[c]	½ to 1 pt		
	*Lorsban-4E[c]	½ to 2 pt		
Sorghum midge	*Asana XL	2.9 to 5.8 oz	Over row	Apply during bloom when 50% of heads have begun to bloom and there is 1 or more midge adults (flies) per head.
	*Baythroid XL	1 to 1.3 oz		
	*Cobalt	7 to 13 oz		
	Dimethoate 4EC[c]	¼ to ½ pt		
	*Lorsban-4E[c]	½ pt		
	*Mustang Max	1.28 to 4 oz		
	*Proaxis	1.92 to 2.56 oz		
	*Warrior	1.92 to 2.56 oz		
Webworms	*Baythroid XL	1.3 to 2.8 oz	Over row	Treat when there are 5 or more larvae per head.
	*Cobalt	19 to 38 oz		
	*Lorsban-4E[c]	1 pt		
	*Mustang Max	1.76 to 4 oz		
	*Proaxis	2.56 to 3.84 oz		
	Tracer	1.5 to 3 oz		
	*Warrior	2.56 to 3.84 oz		
Yellow sugarcane aphid	*Cobalt	7 to 13 oz	Over row	Sprays should be applied at first sign of damage to seedling sorghum; 5 to 10 aphids per leaf.
	Dimethoate 4EC[c]	½ to 1 pt		
	*Lorsban-4E[c]	½ to 1 pt		

*Use restricted to certified applicators.

[a]The formulation of the product most commonly used in Illinois is listed. If you use another formulation, *read the label* to determine the amount of product per acre. Also, read the product label for precautions and restrictions.

[b]The economic thresholds indicated are nominal (based on experience) or simple (based on research regarding the average response of the crop to insect injury). Dynamic thresholds that vary with cost of control, expected yield, crop value, and other variables have been developed for some insect pests. These dynamic thesholds often are published in newsletters during the growing season (refer to Web addresses on page 2.)

[c]Some sorghum varieties are sensitive to organophosphate insecticides.

Table 5. Insecticides for small grains (barley, oats, rye, wheat)

Insect	Insecticide[a]	Amount of product per acre[a]	Placement	Timing of application, comments[b]
Aphids (English grain aphid, greenbug, bird cherry-oat aphid)	*Baythroid XL Dimethoate 4EC *Penncap-M *Proaxis *Warrior	1.8 to 2.4 oz ½ to ¾ pt 2 to 3 pt 2.56 to 3.84 oz 2.56 to 3.84 oz	On foliage	Treat when there are 12 to 15 aphids per tiller during seedling to boot stage. Baythroid, Dimethoate, Proaxis, and Warrior are labeled for use only in wheat. Do not use Penncap-M in rye.
Armyworm	*Mustang Max *Penncap-M *Proaxis Tracer *Warrior	1.76 to 4 oz 2 to 3 pt 2.56 to 3.84 oz 1 to 3 oz 2.56 to 3.84 oz	On foliage	Treat when there are 6 or more nonparasitized armyworms (¾ to 1¼ inches long) per linear foot of row and before extensive head cutting occurs. Do not use Penncap-M in rye. Baythroid, Mustang Max, Proaxis, and Warrior are labeled for use only in wheat.
Cereal leaf beetle	*Baythroid XL *Mustang Max *Proaxis Sevin XLR Plus Tracer *Warrior	1 to 1.8 oz 1.76 to 4 oz 2.56 to 3.84 oz 1 qt 1 to 3 oz 2.56 to 3.84 oz	On foliage	Treat when the combination of eggs and larvae averages 3 or more per stem. Baythroid, Mustang Max, Proaxis, Sevin, and Warrior are labeled for use only in wheat.
Grasshoppers	*Baythroid XL Dimethoate 4EC *Mustang Max *Penncap-M *Proaxis Sevin XLR Plus *Warrior	1.8 to 2.4 oz ¾ pt 3.2 to 4 oz 2 to 3 pt 2.56 to 3.84 oz ½ to 1½ qt 2.56 to 3.84 oz	On foliage	During fall when damage is apparent, treat field borders and noncrop areas to stop migration. Do not use Penncap-M in rye. Baythroid, Dimethoate, Mustang Max, Proaxis, Sevin, and Warrior are labeled for use only in wheat.

*Use restricted to certified applicators.

[a]The formulation of the product most commonly used in Illinois is listed. If you use another formulation, *read the label* to determine the amount of product per acre. Also, read the product label for precautions and restrictions.

[b]The economic thresholds indicated are nominal (based on experience) or simple (based on research regarding the average response of the crop to insect injury). Dynamic thresholds that vary with cost of control, expected yield, crop value, and other variables have been developed for some insect pests. These dynamic thesholds often are published in newsletters during the growing season (refer to Web addresses on page 2.)

Table 6. Insecticides for grass hay or pasture

Insect	Insecticide[a]	Amount of product per acre[a]	Placement	Timing of application, comments[b]
Armyworm	Sevin XLR Plus Tracer	1 to 1½ qt 1 to 2 oz	On foliage	Do not apply when weeds are blooming.
Grasshoppers	Sevin XLR Plus	1 to 1½ qt	On foliage	Treat when there are 15 to 20 grasshoppers per square yard. Do not apply when weeds are blooming.

[a]The formulation of the product most commonly used in Illinois is listed. If you use another formulation, *read the label* to determine the amount of product per acre. Also, read the product label for precautions and restrictions.
[b]The economic thresholds indicated are nominal (based on experience) or simple (based on research regarding the average response of the crop to insect injury). dynamic thresholds that vary with cost of control, expected yield, crop value, and other variables have been developed for some insects pests. These dynamic thesholds often are published in newsletters during the growing season (refer to Web addresses on page 2.)

Table 7. Insecticides for noncrop areas

To avoid injury to bees, do not apply sprays to noncrop areas if weeds are blooming.

Insect	Insecticide[a]	Amount of product per acre[a]	Placement	Timing of application, comments[b]
Grasshoppers	*Asana XL Imidan 70W Sevin XLR Plus	2.9 to 5.8 oz 2⅛ to 2¾ lb ½ to 1½ qt	On foliage	Treat when grasshopper nymphs average 15 to 20 per square yard along roadsides and fencerows. Apply treatments while hoppers are small and before they migrate into row crops. Do not spray areas adjacent to water or where runoff is likely to occur. Do not spray ditch banks.

*Use restricted to certified applicators.
[a]The formulation of the product most commonly used in Illinois is listed. If you use another formulation, *read the label* to determine the amount of product per acre. Also, read the product label for precautions and restrictions.
[b]The economic thresholds indicated are nominal (based on experience) or simple (based on research regarding the average response of the crop to insect injury). Dynamic thresholds that vary with cost of control, expected yield, crop value, and other variables have been developed for some insect pests. These dynamic thesholds often are published in newsletters during the growing season (refer to Web addresses on page 2.)

2

Weed Control for Corn, Soybeans, and Sorghum

This guide is based on the results of research conducted by the personnel of the University of Illinois Agricultural Experiment Station, other experiment stations, and the U.S. Department of Agriculture (USDA). The soils, crops, and weed problems of Illinois have been given primary consideration.

The user should have an understanding of cultural and mechanical weed control. As these practices change little from year to year, this chapter focuses on making practical, economical, and environmentally sound decisions regarding herbicide use.

Most of the suggestions in this guide are intended primarily for ground applications. For aerial applications, such factors as carrier volume and adjuvant selection may differ.

Precautions

The benefits of chemical weed control must be weighed against the potential risks to crops, people, and the environment. Discriminate use should minimize exposure of humans and livestock, as well as desirable plants. Risks can be reduced by observing current label precautions.

Current Label

Precautions and directions for use may change. Herbicides classified as restricted use pesticides (RUPs) must be applied by certified applicators (Table 4). Use of these herbicides may be restricted because they are toxic or pose environmental hazards. The degree of toxicity is indicated by the signal word on the label.

Signal Word

Heed the accompanying precautions. The signal words for herbicides discussed in this chapter are given in Table 4. "Danger–Poison" and "Danger" indicate high toxicity hazards, whereas "Warning" indicates moderate toxicity. Always use personal protective equipment (PPE) as specified on the herbicide label for handling and application. Keep persons or animals not directly involved in the operation out of the area. Observe reentry intervals (REIs) as specified on the label. "Agricultural Use Requirement" on the label may require posting of the treated area. Use special drift precautions near residential areas.

Environmental Hazards

Groundwater advisories (Table 4) must be observed, especially on sandy soils with a high water table. The threat of toxicity to fish and wildlife is indicated under "Environmental Hazards" on the herbicide label. Hazards to endangered species may be indicated.

Proper Herbicide Use

Apply only to approved crops at the proper rate and time. Illegal residues can result from overapplication or improper timing. Observe the recommended harvesting or grazing intervals after treatment.

Proper Equipment Use

Make sure that spray tanks are clean and free of other pesticide residues. Many herbicide labels provide cleaning suggestions, which are particularly important when spraying different crops with the same sprayer and especially when using postemergence herbicides.

The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.

Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.

Correctly calibrate and adjust the sprayer before adding the herbicide to the tank.

Proper Drift Precautions

Spray only on relatively calm days when the wind is light. Make sure the wind is not moving toward areas of human activity, susceptible crops, or ornamental plants. Nearby residential areas and fields of edible horticultural crops deserve special attention. *Use special precautions with 2,4-D, Banvel or Clarity, Celebrity Plus, Command 3ME, Distinct, glyphosate (many trade names), Gramoxone Inteon, Hornet WDG, Marksman, NorthStar, Shotgun, and Stinger,* as symptoms of injury have occurred far from the application site.

Precautions to Protect the Crop

Avoid applying a herbicide to crops under stress or predisposed to injury. Crop sensitivity varies with size of the crop and climatic conditions as well as previous injury from plant diseases, insects, or chemicals.

Proper Recropping Interval

Failure to observe the proper recropping intervals may result in carryover injury to the next crop. Soil texture, organic matter, and pH may affect herbicide persistence. Check Tables 5a and 5b and current labels for recropping restrictions.

Proper Storage

Promptly return unused herbicides to a safe storage place. Pesticides should be stored in their original, labeled containers in a secure place away from unauthorized people (particularly children) and livestock and their food or feed.

Proper Container Disposal

Containers for liquids should be pressure- or triple-rinsed. Properly rinsed containers can be recycled and may be accepted by some sanitary landfills. Haul paper containers to a sanitary landfill or burn them in an approved manner. If possible, use mini-bulk returnable containers.

Cultural and Mechanical Control

Good cultural practices that aid in weed control include adequate seedbed preparation, adequate fertilization, crop rotation, planting on the proper date, using the optimal row width, and seeding at the rate required for optimal stands.

Planting in relatively warm soil can help the crop emerge quickly and compete better with weeds. Good weed control during the first 3 to 5 weeks is extremely important for both corn and soybeans, as they usually compete quite well with most of the weeds that begin growing later. Narrow rows help the crop compete better with the weeds. However, if herbicides alone cannot give adequate weed control, then keep rows wide enough to allow for cultivation.

If adequate rainfall does not occur after the application of a soil-applied herbicide, use a rotary hoe after weed seeds have germinated but before most weeds have emerged. Operate it at 8 to 12 miles per hour, and weight it enough to stir the soil and kill the tiny weeds. Rotary hoeing also aids crop emergence if the soil is crusted.

Row cultivators also should be used while weeds are small. Throwing soil into the row can help smother small weeds. Proper adjustment of equipment (speed, depth, and angle) is essential for minimizing crop injury and pruning crop roots. Cultivation may not be needed where herbicides are adequately controlling weeds unless the soil is crusted or needs aeration.

Herbicide Incorporation

Trifluralin is incorporated to minimize surface loss. Other soil-applied herbicides may be incorporated to minimize dependence on timely rainfall or to improve control of certain weed species.

Incorporation should place the herbicide uniformly throughout the top 1 to 2 inches of soil for the best control of most weeds. Slightly deeper placement may improve the control of certain weeds under relatively dry conditions but may dilute the herbicide and reduce its effectiveness. Incorporation tools usually distribute most of the herbicide into the soil to about one-half the depth of operation. Thus, for most herbicides, the suggested depth of operation is 3 to 4 inches for most tillage tools.

Thorough incorporation often requires two passes, but the second pass may be delayed if the first pass adequately reduces surface loss of the herbicide. The second pass should be at an angle to the first pass and no deeper. Single-pass incorporation may be adequate, especially if rotary hoeing, cultivation, or subsequent herbicide treatment maintains adequate weed control.

Accurate application and uniform distribution help minimize crop injury and carryover problems. Uniform distribution depends on the type of equipment used, the depth and speed of operation, the texture of the soil, and the amount of soil moisture. Field cultivators, tandem disks, and disk–chisels or other combination tools are sometimes used for incorporation. More uniform herbicide distribution is provided by two passes than one, whether with a field cultivator or tandem disk.

Field Cultivators

Field cultivators used for herbicide incorporation need at least three rows of shanks equipped with sweeps (not points), each with an effective working space of 7 inches or less. Sweeps for C-shank cultivators should be at least as wide as the effective shank spacing. Set the equipment to cut in a level position at 3 to 4 inches deep and to operate at a minimum of 5 miles per hour.

Tandem Disks

Tandem disks used for herbicide incorporation should have disk-blade diameters of 20 inches or less and blade spacings of 7 to 9 inches. *Do not use larger disks for incorporating herbicides.* Set the disk to cut 3 to 4 inches deep, and operate at 4 to 6 miles per hour or a speed sufficient to move soil the full width of the blade spacing. Slower speeds or lack of a leveling device can result in herbicide streaking.

Combination Tools

Several tillage tools combine disk gangs, field cultivator shanks, and leveling devices. Many combination tools can handle large amounts of surface residue without clogging and yet leave adequate crop residue on the soil surface for erosion control. Results indicate that these combination tools may provide more uniform one-pass incorporation than a disk or field cultivator, but one pass with them is generally no better than two passes with the disk or field cultivator.

Chemical Weed Control

Plan your weed-control program to fit your soils, tillage program, crops, weed problems, and farming operations. Good herbicide performance depends on the weather and on wise selection and application. Your decisions about herbicide use should be based on the nature and seriousness of your weed problems. The herbicide susceptibility of common weed species is indicated in several tables in this guide.

Corn and soybean are occasionally injured by herbicides applied to these crops. To minimize crop injury, apply the herbicide uniformly at the stage of crop growth specified on the label and at the correct rate (see the section on "Herbicide Rates"). Crop tolerance ratings for various herbicides are also given in the tables in this chapter. Unfavorable conditions such as cool, wet weather; delayed crop emergence; deep planting; seedling diseases; soil in poor physical condition; and poor-quality seed may contribute to crop stress and herbicide injury. Hybrids and varieties vary also in their tolerance to herbicides and environmental stress factors. Once injured by a herbicide, plants may be more prone to disease.

Crop-planting options for the next season also must be considered when selecting a herbicide program. Corn and soybean herbicides may have restrictive recropping intervals for some agronomic and many vegetable crops. Tables 5a and 5b cover recropping intervals for the major agronomic crops grown in Illinois, but always check the label. Recropping intervals may be extended for previous, subsequent, or late-summer herbicide applications as well as droughty weather or soil pH. Command or Scepter (in northern Illinois) can restrict planting wheat after soybean, whereas atrazine restricts planting wheat after corn. For soybean, the persistent corn herbicides of concern are atrazine, clopyralid, and prosul-furon. STS soybeans may help reduce the carryover problem with prosulfuron. Special concerns are rate and date of application, as well as rainfall amount and soil pH. When corn follows soybean, the major concerns are imazaquin and chlorimuron; but some corn hybrids may minimize this concern (see the label). Be sure that the application of persistent herbicides is uniform and properly timed to minimize injury to wheat or corn. Refer to the herbicide label for information about cropping sequence and appropriate recropping intervals.

For some herbicides, different formulations and concentrations are available under the same trade name. *No endorsement of any trade name is implied, nor is discrimination against similar products intended.*

Weed Resistance to Herbicides

One of the disadvantages of chemical weed control is that weeds can become resistant to herbicides. Herbicide resistance is presently a problem in Illinois. There are triazine-resistant pigweed, waterhemp, lambsquarters, and kochia, as well as acetolactate synthase (ALS)–resistant waterhemp, kochia, cocklebur, ragweed, eastern black nightshade, giant foxtail, and shattercane. There is also diphenylether-resistant (PPO) waterhemp and glyphosate-resistant horseweed (marestail). All of these hebicides have been widely used in Illinois; and if not managed properly, the problem of herbicide-resistant weeds has the potential to increase.

Certain management strategies can help deter the development of herbicide-resistant weeds:

1. Scout fields regularly to identify resistant weeds. Monitor changes in weed populations to restrict the spread of herbicide-resistant weeds.
2. Rotate herbicides with different sites of action. Do not make more than two consecutive applications of herbicides (whether within the same year or in successive years) with the same site of action against the same weed. Instead, include other

effective management strategies for weed control. This approach is especially critical when using herbicide-resistant crops.

3. Use multiple sites of action (tank mix, premix, or sequential) that effectively control potentially resistant weeds.
4. Where practical, use rotary hoeing and cultivation to control weed escapes. If necessary, use hand weeding to minimize the spread of herbicide-resistant weeds.
5. Be aware that resistant weeds can spread from total-vegetation-control (TVC) programs used along highway, railroad, or utility rights-of-way areas near your farm.

For further information on the causes of herbicide resistance and strategies to minimize it, visit your local Extension office or see Chapter 12, "Weed Resistance to Herbicides," in the current edition of the *Illinois Agricultural Pest Management Handbook.*

Herbicide Combinations

Herbicide combinations (tank mixes, premixes, or sequential applications) can control more weed species, reduce carryover, and reduce crop injury. Some labels allow split applications (the same herbicide applied at different times) or sequential applications (different herbicides applied at different times). Numerous combinations of herbicides are sold as premixes, and some are tank-mixed. Registered premixes are shown in Tables 6 and 7 in this chapter. Tank-mixing allows you to adjust the ratio of herbicides to fit local weed and soil conditions, whereas premixes may overcome some of the compatibility problems found with tank-mixing. When using a tank mix, you must follow restrictions for all products used in the combination.

Problems may occur when mixing emulsifiable-concentrate (EC) formulations with suspendible herbicides, such as liquid-flowable (L) or dry-flowable (DF) formulations. Proper mixing procedure may minimize these problems. The label of most soil-applied herbicides specifies a compatibility test when a liquid fertilizer carrier is used. First, fill tanks at least one-fourth full with carrier (water or liquid fertilizer) and start tank agitation. Next, if needed, add the compatibility agent at the rate indicated by the test or adjuvant label. Add suspendible herbicide formulations as just described and completely suspend (thoroughly mix) before adding emulsifiable concentrates. Mix ECs with equal volumes of water (thoroughly emulsify) before adding them to the tank. Add soluble formulations (those that do not emulsify or disperse) last. Empty and clean spray tanks often enough to prevent accumulation of material on the sides and bottom of the tank.

Herbicide Rates

Herbicide rates vary according to the time and method of application, soil conditions, tillage system used, and seriousness of the weed infestation. Rates of individual components within a combination are usually lower than rates for the same herbicides used alone.

The rates for soil-applied herbicides often vary with the texture of the soil and the amount of organic matter the soil contains. For sandy soils, the herbicide label may specify reducing the rate or not using any if crop tolerance to the herbicide is marginal. Postemergence rates often vary, depending on the size and species of the weeds.

The rates given in this chapter are, unless otherwise specified, broadcast rates for the amount of formulated product. If you plan to band or direct herbicides, adjust the amount per crop acre according to the percentage of the area actually treated. Herbicides may have formulations with different concentrations of the active ingredient. Be sure to read the label and make necessary adjustments when changing formulations.

Postemergence Herbicide Principles

Postemergence herbicides applied to growing weeds generally have foliar rather than soil activity; however, some may have both. The rates and timing of applications are based on weed size and climatic conditions. When weeds are small, they usually can be controlled with lower application rates. Larger weeds often require higher herbicide rates. Herbicide penetration and action are usually greater with warm temperature and high relative humidity. Rainfall occurring too soon after application (0.5 to 6 hours, depending on the herbicide) can reduce weed control.

Translocated herbicides are most effective at lower spray volumes (5 to 20 gallons per acre), whereas contact herbicides require more complete coverage. Foliar coverage increases as water volume and spray pressure are increased. Spray nozzles that produce small droplets also improve coverage. For contact herbicides, labels usually specify to use 10 to 40 gallons of water per acre for ground application and a minimum of 5 gallons per acre for aerial application. Spray pressures of 30 to 60 psi are often suggested with flat-fan or hollow-cone nozzles to produce small droplets and improve canopy penetration. *These small droplets are subject to drift.*

Crop size limitations may be specified on the label to minimize crop injury and maximize weed control. If weeds are smaller than the crop, basal-directed sprays may minimize crop injury because they place more herbicide on the weeds than on the crop. If the weeds are taller than the crop, rope-wick or sponge-type applicators may be used to place the herbicide

on top of the weeds and minimize contact with the crop. Follow the label directions and precautions for each herbicide.

Herbicide adjuvants, such as crop-oil concentrate (COC), nonionic surfactant (NIS), or ammonium fertilizer, may be specified on the herbicide label. Crop-oil concentrates spread the herbicide across the leaf surface, keep the surface moist longer, and aid penetration into the cuticle. COCs are phytobland oils with emulsifier (surfactant) added to allow better mixing with water. The oil may be of petroleum (POC) or vegetable (VOC) origin. Methylated seed oils (MSO) are esters of fatty acids formulated to provide better performance than a conventional VOC. Most labels allow POC, MSO, or VOC. COCs are used at 1 to 3 pints per acre or about 1 percent on a volume basis. Oils generally have a greater postemergence effect than surfactants do *on both weeds and crops.*

Surfactants cause a spreading and wetting action by decreasing the surface tension of water, allowing the spray mix to spread over waxy or hairy leaf surfaces rather than forming droplets. Because more leaf surface is covered, more herbicide may be absorbed. Surfactants may contain fatty acids to improve penetration. Labels may specify that the NIS should contain a minimum of 75 to 85 percent active ingredient or else you should use a higher surfactant rate. An NIS usually is applied at 0.25 to 1 pint per acre or ⅛ to ½ percent on a volume-to-volume basis.

Ammonium fertilizers are added to increase herbicide activity on weed species such as velvetleaf. Ammonium sulfate and urea–ammonium nitrate solution (28-0-0 UAN) are the most common fertilizer adjuvants, although ammonium polyphosphate (10-34-0 APP) may also be specified. UAN usually is used at 2 to 4 quarts per acre. Labels for contact herbicides may specify that a fertilizer adjuvant replace an NIS or a COC, while translocated herbicides usually specify UAN in addition to an NIS or a COC.

Drift-reduction agents are added to the spray tank to reduce small-droplet formation and thus reduce spray-particle drift. See the adjuvant label for rates, as drift retardants vary greatly in formulation.

Conservation Tillage and Weed Control

Conservation tillage allows crop production, while reducing soil erosion by protecting the soil surface with plant residue. Minimum or reduced tillage refers to any tillage system leaving crop residue on the soil surface, including primary tillage with chisel plows or disks and the use of field cultivators, disks, or combination tools for secondary tillage. Mulch tillage is reduced tillage that leaves at least 30 percent of the soil surface covered with plant residue.

Ridge tillage and zero tillage are conservation tillage systems with no major tillage prior to planting. In ridge tillage, conditions are often ideal for banding preemergence herbicides because cultivation is a part of the system. "No-till" is actually "slot tillage" for planting with no overall primary or secondary tillage. No-till planting conserves moisture, soil, and fuel. It also allows timely planting of soybeans or sorghum after winter wheat harvest (double-cropping).

If tillage before planting is eliminated, undesirable existing vegetation must be controlled with herbicides before, at, or after planting. The elimination or reduction of preplant tillage and row cultivation puts a greater reliance on chemical weed control. Greater emphasis may be placed on preplant or postplant soil-applied herbicides that are not incorporated or on foliar-applied herbicides. Herbicides are available to allow "total postemergence" weed control in corn and soybeans.

Where primary tillage is minimized, soil-residual herbicides applied several weeks before planting may reduce the need for a "burndown" herbicide. However, early preplant (EPP) application may require additional preemergence or postemergence herbicides or cultivation for satisfactory weed control after planting.

Corn and soybean are the primary crops in Illinois, and they are often planted in sequence. Modern equipment allows successful no-till planting in corn and soybean stubble. The use of a disk or chisel plow on corn stubble may still provide adequate crop residue to meet mulch-till requirements.

Soybean stubble is often ideal for minimum- or zero-tillage production systems. Primary tillage is rarely needed, and the crop residue, if properly spread, should not interfere with herbicide distribution. Early preplant application of preemergence herbicides or the use of postemergence herbicides often provides adequate weed control.

The existing vegetation in corn and soybean stubble is usually annual weeds. If small, weeds often can be controlled before planting with herbicides that have both foliar and soil-residual activity. In cases where annual vegetation is more than 2 to 3 inches tall at planting, either a contact or translocated broad-spectrum herbicide (such as paraquat or glyphosate) can be added to the spray tank. If the problem is broadleaf weeds, 2,4-D or dicamba may be used prior to planting corn or no-till soybeans, *but observe the planting delay specifications.* Herbicides that can be used prior to planting to control existing vegetation are listed in Tables 1, 2, and 3.

Some growers in Illinois are using annual cover crops not only to control weed problems at planting but also for erosion control. Annual cover crops in Illinois are hairy vetch, winter rye, and winter wheat. Hairy vetch, a winter annual legume, is easily con-

trolled with 2,4-D or dicamba before planting corn. Winter rye or winter wheat can be controlled by glyphosate prior to planting corn or soybeans. Cover crops should be controlled prior to planting crops, but the question is "How early do we do this?" If the season is dry, late control depletes soil moisture for crop establishment; but if the season is wet, late control helps dry out the soil. Decomposing residue of small-grain cover crops can sometimes inhibit corn seedlings.

Perennial sods require a different approach. It is estimated that 65 to 70 percent of the Conservation Reserve Program (CRP) acres in the Corn Belt may return to cropland. Many of these acres have been planted to perennial grass or legume sods. The questions here are these: What is the best way to control sod species? What is the best timing for control, and what are the best cropping choices? *Sods should be killed prior to planting crops into them* (Table 10).

Perennial grass sods were planted on much of the CRP land. Glyphosate provides the best "sod grass" control. *Fall application is more effective than spring application.* Mowing the sod in late summer allows adequate regrowth for timely fall application. Active regrowth should be 6 to 8 inches before fall application. Springtime applications must be delayed to obtain 6 to 10 inches of new growth for effective control. In the spring, paraquat (Gramoxone Inteon) + atrazine is often as effective as glyphosate for controlling several grass species (Table 10). Preplant glyphosate rates may be reduced if followed with atrazine at corn planting. If grass–legume mixes are established, the legume component must also be controlled.

Perennial legume sods must have 6 to 8 inches of new growth for effective control. *Do not take a spring cutting before controlling legumes,* as this delays corn planting. Corn better utilizes legume nitrogen and allows preplant or postemergence use of 2,4-D or dicamba. Dicamba controls alfalfa better than 2,4-D does, but either controls red clover. When glyphosate is used, adding dicamba improves alfalfa control, and adding 2,4-D improves dandelion control. Glyphosate may be applied before the last alfalfa cutting in the fall or spring. Clover sods may be controlled by atrazine (see Tables 9 and 10).

Fall Herbicide Applications

The practice of applying herbicides in the fall has been increasing in Illinois. Growers are using two very different approaches to fall herbicide applications. The first approach is to apply soil-applied grass herbicides, such as metolachlor, flufenacet, dimethenamid, or pendimethalin, to control annual grass species the following season. These herbicide applications are generally made north of Interstate 80, in conventional tillage fields, and after soil temperatures decrease to 50°F but before the ground freezes. The reasoning behind these fall herbicide applications is to spread the workload out for the applicators, as well as to ensure adequate precipitation for incorporation of these herbicides. There are disadvantages to these types of applications: first, they require higher herbicide application rates and, second, the grass control may not last throughout the entire growing season due to herbicide dissipation. There are several herbicides that can be used in the fall for annual grass control. These herbicides are identified in Tables 1 and 3 (see the "Application timings" section in these tables).

The second approach to fall herbicide applications is to control winter annual and perennial weeds in no-till corn and soybean fields. This approach is used primarily by growers who have had difficulty controlling winter annual and perennial weeds in no-till fields in the spring. Winter annual weeds, such as purple deadnettle, henbit, chickweed, horseweed (marestail), and a number of mustard species, can form a dense weed mat that can be difficult to control with spring burndown herbicides. These problems can result from insufficient spray coverage, fluctuating spring temperatures, and timeliness of the application due to uncooperative spring weather.

Controlling winter annual and simple perennial weeds in the fall has a number of potential benefits. This practice can prevent dense mats of winter annual weeds that can physically interfere with planting and tillage, can reduce vegetation where insects may harbor, and can possibly allow earlier planting due to faster soil drying and warming. In addition, controlling these weeds in the fall prevents them from producing seed, thereby decreasing the soil seed bank and helping reduce future problems with these species. Fall control of simple perennials, such as dandelion and white cockle, is much more effective than controlling these weeds in the spring. In the fall, food reserves in these perennials are being moved to the roots. When a systemic herbicide is applied, that herbicide moves with the food reserves to the roots and can cause complete control of the roots. Additionally, higher rates of some translocated herbicides (such as 2,4-D) can be used in the fall, thus allowing for greater control of perennial weeds like dandelion.

There are currently three basic strategies to control winter annual weeds with fall herbicide applications: (1) apply a herbicide with residual soil activity before most of the winter annual weed species germinate; (2) apply a nonresidual herbicide, such as glyphosate, 2,4-D, or paraquat (Gramoxone Inteon), to emerged winter annual, biennial, and perennial weeds while they are still relatively small or in the rosette stage;

and (3) use a combination of strategies 1 and 2. The goal of all of these strategies is to reduce the amount of total vegetation that needs to be dealt with in the spring prior to planting, possibly even eliminating the need for a burndown herbicide application. While these approaches sound good in theory, the actual end results may or may not be as good as expected. Several factors, such as herbicide selection, application rate, weather conditions, and time of planting, ultimately determine how well this system works.

Fall herbicide treatments can be an extremely effective tool in managing winter annual, biennial, and simple perennial weeds. So how do you know if fall herbicide applications are suitable for your farming operation? These applications are most effective on fields where these weeds have been a problem in the past. If spring herbicide treatments have been effectively controlling these species and they do not appear to be increasing, fall herbicide applications may provide little or no benefit in these fields. It is also important to note that, even though winter annual weeds may be controlled by fall applications, under certain conditions a spring burndown treatment may still be needed. Herbicides that can be applied in the fall for winter annual weed control are identified in Tables 1 and 3 (see the "Application timings" section in these tables).

Recommended Web Resources

http://www.cdms.net
This is an excellent index of chemical companies involved in agriculture that is searchable by product (trade name). It contains links to the companies' Web sites and is a good resource for obtaining current product label recommendations.

http://www.greenbook.net
This Web site contains extensive information on pesticides, including current pesticide labels and material safety data sheets.

Tables

Contributions of other weed scientists and staff of the University of Illinois and at other institutions, as well as the input of industry weed scientists, are gratefully acknowledged.

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Table 1. Corn herbicides (Read and follow label directions before using product.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
2,4-D Amine (many trade names)	3.8 lb a.e. (many)	1 to 2 pt 2 to 3 pt 0.5 to 1.0 pt 1 to 1.5 pt	**PP:** Apply from 7 to 14 days before planting. **PRE:** Apply from 3 to 5 days after planting but before corn emerges. **POST:** Apply to corn up to 8 in. tall. **POST-directed:** Apply to corn more than 8 in. tall.	• Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25). • PP and PRE applications are to control existing vegetation prior to corn emergence. • Registered for use on field and sweet corn. • *Do not* apply PP or PRE on light, sandy soils. • *Do not* spray corn from tassel to dough stage. • Corn is brittle 1 to 2 weeks following application and may be susceptible to breakage from wind or cultivation. • Corn hybrids differ in their sensitivity to 2,4-D. • *Do not* forage for feed fodder for 7 days after application. • Spray particles can drift and cause injury to susceptible plants.
2,4-D Ester (many trade names)	3.8 lb a.e. (many)	1 to 2 pt 2 to 4 pt 0.5 to 0.75 pt 0.5 to 0.75 pt 1 to 2 pt	**PP:** Apply from 7 to 14 days before planting. **PRE:** Apply from 3 to 5 days after planting but before corn emerges. **POST:** Apply to corn up to 8 in. tall. **POST-directed:** Apply to corn more than 8 in. tall. **Preharvest:** Apply after dent stage.	• Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25). • Registered for use on field corn. • Use 0.75 pt/A for control of perennial weeds. • 2,4-D ester can volatilize if temperatures exceed 85°F. • *See "Remarks and limitations" for 2,4-D Amine.*
AAtrex, Atrazine atrazine	4L 90DF	0.5 to 2.0 lb a.i.	**EPP:** Apply up to 45 days before planting except on coarse-textured soils. **PPI:** Apply up to 14 days before planting. **PRE:** Apply before crop and weeds emerge. **POST:** Apply to corn up to 12 in. tall.	• Controls annual broadleaf and certain grass weeds (Table 14). • Atrazine is a restricted use pesticide (RUP). • *Do not* apply more than 2.5 lb a.i. atrazine/A in a calendar year. • *Do not* apply more than 1.6 lb a.i. atrazine/A/application on highly erodible soils with less than 30% residue cover. • *Do not* apply more than 2.0 lb a.i. atrazine/A/application on soils that are not highly erodible or on highly erodible soils with at least 30% residue cover.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
AAtrex, Atrazine (cont.)				• Risk of carryover is greater on soils with pH greater than 7.2. • POST applications should include a COC.
Accent nicosulfuron	75WDG	0.33 to 1.33 oz	**POST:** Apply to field corn up to 20 in. tall or through the V6 stage, whichever is more restrictive. **POST-directed:** Apply to field corn from 20 to 36 in. tall or before the V10 stage, whichever is more restrictive.	• Controls grass weed species (Table 12). • Registered for use on field corn, field corn grown for seed, popcorn, and sweet corn. • See Table 16 for compatibility with soil insecticides. • Must include a COC or an NIS; the addition of a nitrogen source is required. • *Do not* apply more than 1.33 oz/A of Accent per year. • *Do not* tank-mix with Basagran, Laddok, or 2,4-D. • Accent will not control ALS-resistant weed species.
Aim carfentrazone	1.9EW	0.5 to 1.0 fl oz	**Preplant Burndown:** Apply prior to planting or within 24 hours after planting. **POST:** Apply to corn up to the V8 stage. **POST-directed:** Apply to corn from the V8 to V14 stage.	• Controls some annual broadleaf weeds (Table 14). • Registered for use on field corn, seed corn, popcorn, corn silage, and sweet corn. • For broad-spectrum weed control, Aim will need to be tank-mixed. • Must include an NIS; under dry conditions, a COC can be used. • The use of a COC will increase corn leaf burn and speckling. • *Do not* apply when air temperatures are abnormally cool, humidity is high, or corn foliage is wet from dew, rainfall, or irrigation.
Autumn iodosulfuron	10WDG	0.3 oz	**Fall:** Apply after fall harvest but before the ground freezes. **EPP:** Apply at least 30 days before planting corn.	• Controls certain winter annual broadleaf weeds (Table 9). • Applications require additions of a COC and a nitrogen fertilizer (UAN or AMS). • Autumn will not provide season-long control of annual grass and broadleaf weed species. • *Do not* use prior to planting sweet corn, popcorn, or corn grown for seed. • *Do not* apply more than 0.3 oz (0.001875 lb a.i.) per acre per year.

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Balance PRO isoxaflutole	4SC	1.5 to 4.5 fl oz	**EPP:** Apply 30 days prior to planting with a planned POST program; otherwise, apply 21 days prior to planting. **PPI:** Apply 30 days prior to planting with a planned POST program; otherwise, apply 21 days prior to planting. **PRE:** Apply prior to crop emergence.	• Controls annual broadleaf and grass weeds (Tables 12 and 14). • Registered for use on field corn. • Balance PRO is a restricted use pesticide (RUP). • *Read* and *observe* all environmental precautions. • Adjust rates according to soil texture and organic matter. • *Do not* apply to emerged corn. • *Do not* apply to very sandy soils. • Corn hybrids vary in their tolerance to Balance PRO. • Balance PRO may be tank-mixed with several herbicides to increase grass control. • Plant corn at least 1.5 inches deep and completely cover seed with soil.
Banvel dicamba	4L	0.5 to 1 pt 1 pt 0.5 to 1 pt 0.5 pt 0.5 pt	**Preplant Burndown:** Apply to actively growing weeds. **PRE:** Apply prior to crop emergence. **EPOST:** Apply to corn from spike up to 8 in. tall or the 5-leaf stage, whichever is more restrictive. **LPOST:** Apply to corn from 8 to 36 in. tall, or 15 days prior to tassel emergence. **POST-directed:** Apply when corn leaves prevent coverage, when sensitive crops are nearby, or when mixing with 2,4-D.	• Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25). • Registered for use on field corn, seed corn, popcorn, and silage corn. • *Do not* apply to seed corn or popcorn without verifying with a local seed company. • *Do not* allow contact with corn seed. • *Do not* apply more than 1.5 pt/A of Banvel per year. • Corn may be harvested or grazed for feed once it has reached the milk stage. • *Do not* apply Banvel when soybeans are growing nearby if corn is more than 24 in. tall, soybeans are more than 10 in. tall, or soybeans have begun to bloom. • *Do not* apply in areas where desirable legumes or broadleaf crops are present. • *Do not* apply PRE on coarse-textured soils.

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate / A	Application timings	Remarks and limitations
Basagran bentazon	4S	1 to 2 pt	**POST:** Apply to actively growing weeds within the size limits listed on the label.	• Controls broadleaf weeds and sedges (Table 14). • Registered for use on field corn, sweet corn, popcorn, and corn grown for seed or silage. • *Do not* graze treated corn for at least 12 days after application. • *Do not* apply more than 4 pt/A of Basagran per year. • *Do not* apply to corn that is injured or under stress. • Include a COC and/or a spray-grade nitrogen source.
Basis 50% rimsulfuron + 25% thifensulfuron	75WDG	0.33 to 0.5 oz 0.5 to 1 oz 0.33 to 1 oz 0.33 oz	**Fall Burndown:** Apply after harvest but before the ground freezes. **EPP:** Apply up to 30 days before planting. **PRE:** Apply after planting but before corn emerges. **EPOST:** Apply to corn from spike through the V2 stage.	• Controls certain grass and broadleaf weeds (Tables 12 and 14). • *Do not* apply to popcorn, sweet corn, or field corn grown for seed. • *Do not* apply more than 1 oz/A of Basis in a 12-month period. • If using more than 0.62 oz/A of Basis, *do not* follow with POST applications of Steadfast or Steadfast ATZ. • See Table 16 for compatibility with soil insecticides. • *Do not* tank-mix with Basagran, Laddok, Beacon, or other ALS-inhibiting herbicides (unless on label). • Applications must include a COC or an NIS with an ammonium fertilizer. • Basis will not control ALS-resistant weed species.
Beacon primisulfuron	75WDG	0.76 oz	**POST:** Apply to corn from 4 to 20 in. tall. **POST-directed:** Drop nozzles may be used on corn from 20 in. tall until tassel emergence.	• Controls annual broadleaf and certain grass weeds (Tables 12 and 14). • *Do not* apply to sweet corn or ornamental corn. • See Table 16 for compatibility with soil insecticides. • *Do not* graze or feed forage from treated areas within 30 days following application. • *Do not* harvest for silage within 45 days after application. • *Do not* harvest for grain within 60 days after application. • Apply with a COC or an NIS. • Beacon will not control ALS-resistant weed species.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Bicep II Magnum 2.4 lb *S*-metolachlor + 3.1 lb atrazine	5.5L	1.3 to 2.6 qt	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply to the surface at planting, before crop and weeds emerge. **EPOST:** Apply to corn up to 5 in. tall. **POST-directed:** Apply POST to corn up to 12 in. tall.	• Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14). • Bicep II Magnum is a restricted use pesticide (RUP). • Registered for use on all types of corn. • This product contains atrazine; follow the use limitations listed under atrazine. • This product contains *S*-metolachlor; follow the use limitations listed under Dual II Magnum. • *Do not* graze or feed forage from treated areas within 60 days after application. • Adjust rates according to soil texture, organic matter, and application timing.
Bicep Lite II Magnum 3.33 lb *S*-metolachlor + 2.67 lb atrazine	6L	0.9 to 2.2 qt	**PP:** Apply up to 45 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply to the surface at planting, before crop and weeds emerge. **EPOST:** Apply to corn up to 5 in. tall. **POST-directed:** Apply POST to corn up to 12 in. tall.	• Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14). • Bicep Lite II Magnum is a restricted use pesticide (RUP). • Bicep Lite II Magnum contains less atrazine than Bicep II Magnum. • *See "Remarks and limitations" for Bicep II Magnum.*
Breakfree acetochlor	6.4EC	1.5 to 3.75 pt	See Surpass application timings.	• Breakfree contains the same active ingredient as Surpass; see *"Remarks and limitations" for Surpass.*
Breakfree ATZ 3 lb acetochlor + 2.25 lb atrazine	5.25L	2.2 to 3.4 qt	See Keystone application timings.	• Breakfree ATZ contains the same active ingredients as Keystone; *see "Remarks and limitations" for Keystone.*
Breakfree ATZ Lite 4 lb acetochlor + 1.5 lb atrazine	5.5L	1.6 to 3 qt	See Keystone LA application timings.	• Breakfree ATZ Lite contains the same active ingredients as Keystone LA; *see "Remarks and limitations" for Keystone LA.*

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Buctril bromoxynil	2EC	1 to 1.5 pt 1 to 2 pt	**PRE:** Apply from before planting until just prior to corn emergence to control existing vegetation. **POST:** Apply after corn emergence but before tassel emergence.	• Controls certain annual broadleaf weeds (Table 14). • Registered for use on field corn and popcorn. • *Do not* harvest for feed or fodder and *do not* graze within 45 days after application. • *Do not* exceed 2 pt/A of Buctril per season. • *Do not* apply to corn before the 4-leaf stage if using rates greater than 1 pt/A. • Use of an adjuvant or liquid fertilizer may cause excessive leaf burn.
Buctril + atrazine 1.0 lb bromoxynil + 2.0 lb atrazine	3L	1.5 to 3 pt 1.5 to 3 pt	**PRE:** Apply from before planting until just prior to corn emergence to control existing vegetation. **POST:** Apply after corn emergence but before corn is 12 in. tall.	• Controls certain annual broadleaf weeds (Table 14). • Buctril + atrazine is a restricted use pesticide (RUP). • Registered for use on field corn and popcorn. • *Do not* harvest for feed or fodder and do not graze within 45 days after application. • *Do not* exceed 4 pt/A of Buctril + atrazine per season. • *Do not* apply to corn before the 4-leaf stage if using rates greater than 2 pt/A. • This product contains atrazine; follow the use limitations listed under atrazine. • Use of an adjuvant or liquid fertilizer may cause excessive leaf burn.
Bullet 2.5 lb alachlor + 1.5 lb atrazine	4ME	2.5 to 4.5 qt	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 7 days before planting. **PRE:** Apply after planting but before crop and weeds emerge. **EPOST:** Apply to corn up to 5 in. tall.	• Controls annual grass and broadleaf weeds (Tables 12 and 14). • Bullet is a restricted use pesticide (RUP). • Registered for use on all types of corn. • This product contains atrazine; follow the use limitations listed under atrazine. • *Do not* make more than two applications of Bullet per year or exceed 6.4 qt/A of Bullet per year. • *Do not* harvest for feed or fodder and *do not* graze within 60 days after application. • Adjust rates according to soil texture and organic matter.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Callisto mesotrione	4SC	6 to 7.7 fl oz 3 fl oz	**PRE:** Apply before crop and weeds emerge. **POST:** Apply to corn up to 30 in. tall or the 8-leaf stage, whichever is more restrictive.	• PRE and POST control of annual broadleaf weeds (Table 14), and POST control of large crabgrass less than 2 in. tall (Table 12). • Registered for use on field corn, production seed corn, silage corn, yellow popcorn, and sweet corn. • Tank-mixing atrazine with Callisto may improve weed control. • POST applications must include a COC and a spray-grade nitrogen source. • *Do not* apply more than 7.7 fl oz/A of Callisto per season. • *Do not* apply POST to ground treated with Lexar, Lumax, or Camix in the same season. • *Do not* apply POST tank-mixed with emulsifiable-concentrate grass herbicides. • Severe corn injury may result if an organophosphate or carbamate insecticide is applied within 7 days before or after a Callisto application.
Celebrity Plus 10.6% nicosulfuron + 17% diflufenzopyr + 42.4% dicamba	70DF	4.7 oz	**POST:** Apply to corn from 4 to 20 in. tall or the V6 stage, whichever is more restrictive. **POST-directed:** Drop nozzles may be used on corn from 20 to 24 in. tall.	• Controls grass and broadleaf weeds (Tables 12, 14, and 25). • Registered for use on field corn. • *Do not* make more than two applications of Celebrity Plus per year or apply more than 9.4 oz/A of Celebrity Plus per year. • *Do not* make sequential applications of Banvel, Clarity, Distinct, or Marksman herbicide within 15 days of an application of Celebrity Plus. • *Do not* exceed 0.67 oz/A of nicosulfuron per application or 1 oz/A per season. • *Do not* exceed 0.5 lb a.i./A of dicamba per application or 0.75 lb a.i./A/season. • *Do not* apply within 32 days of forage harvest or 72 days of corn grain or stover harvest. • *Do not* apply in areas where desirable legumes or broadleaf crops are present. • Apply with an NIS and an ammonium nitrogen fertilizer.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Clarity dicamba	4L	0.5 to 1 pt 1 pt 0.5 to 1 pt 0.5 pt	**Preplant Burndown:** Apply to actively growing weeds. **PRE:** Apply prior to crop emergence. **EPOST:** Apply to corn from emergence up to 8 in. tall or the 5-leaf stage, whichever is more restrictive. **LPOST:** Apply to corn from 8 to 36 in. tall, or 15 days prior to tassel emergence. **POST-directed:** Apply when corn leaves prevent coverage, when sensitive crops are nearby, or when mixing with 2,4-D.	• Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25). • Registered for use on field corn, seed corn, popcorn, and silage corn. • *Do not* apply to seed corn or popcorn without verifying tolerance with a local seed company. • *Do not* allow contact with corn seed. • *Do not* apply PRE on coarse-textured soils. • *Do not* make more than two applications of Clarity in a growing season. • Corn may be harvested or grazed for feed once it has reached the milk stage. • Avoid using COCs after crop emergence. Use COCs only in dry conditions or when corn is less than 5 in. tall. • *Do not* apply Clarity when soybeans are growing nearby if corn is more than 24 in. tall, soybeans are more than 10 in. tall, or soybeans have begun to bloom. • *Do not* apply in areas where desirable legumes or broadleaf crops are present.
Define flufenacet	4SC	15 to 25 fl oz	**Fall:** Apply north of Illinois Route 136 after October 15. **EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply after planting but before crop and weeds emerge. **POST:** Apply from emergence through the fifth leaf collar.	• Controls annual grass weeds (Table 12). • *Do not* use on popcorn or sweet corn. • *Do not* apply more than 25 oz/A of Define per season. • Plant corn at least 1.5 in. deep. • Adjust rates according to soil texture, organic matter, and application timing. • *Do not* harvest corn forage within 75 days after a POST application. • *Will not control emerged weeds.*
Degree acetochlor	3.8CS	2.25 to 5.5 pt	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 14 days before planting. *(continues)*	• Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12). • Degree is a restricted use pesticide (RUP).

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Degree (cont.)			**PRE:** Apply to the surface at planting, before crop and weeds emerge, and within 5 days after the last preplant tillage operation. **POST:** Apply to corn up to 11 in. tall.	• Registered for use on field corn, production seed corn, silage corn, and popcorn. • *Read* and *observe* all environmental precautions. • Adjust rates according to soil texture, organic matter, and application timing. • *Will not control emerged weeds.*
Degree Xtra 2.7 lb acetochlor + 1.34 lb atrazine	4.04CS	2.9 to 4.3 qt	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply to the surface at planting, before crop and weeds emerge, and within 5 days after the last preplant tillage operation. **POST:** Apply to corn up to 11 in. tall.	• Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14). • Degree Xtra is a restricted use pesticide (RUP). • Registered for use on field corn, production seed corn, silage corn, and popcorn. • *Read* and *observe* all environmental precautions. • This product contains atrazine; follow the use limitations listed under atrazine. • Adjust rates according to soil texture, organic matter, and application timing. • *Do not* graze or feed forage from treated areas within 60 days after application.
Distinct 20% diflufenzopyr + 50% dicamba	70WDG	6 oz 4 oz 4 oz	**EPOST:** Apply to corn from 4 to 10 in. tall. **POST:** Apply to corn from 10 to 24 in. tall. **POST-directed:** Apply to corn 24 to 36 in. tall.	• Controls annual and perennial broadleaf weeds (Tables 14 and 25). • Registered for use on field corn, silage corn, and popcorn. • Distinct should be used sequentially or tank-mixed with a grass herbicide for a complete weed control program. • POST applications must include an NIS and a spray-grade nitrogen source. • *Do not* apply more than 10 oz/A of Distinct per year. • Allow a minimum of 15 days between sequential applications of Distinct. • *Do not* plant any crops except corn within 30 days after application; corn can be replanted 7 or more days after application. • *Do not* use a COC/MSO with Distinct unless specified for certain tank mixes.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Dual II Magnum *S*-metolachlor	7.64EC	1 to 2 pt	**Fall:** Apply north of Illinois Route 136 after October 31. **EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply before crop and weeds emerge. **POST:** May be applied to corn up to 40 in. tall.	• Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12). • Registered for use on all types of corn. • *Do not* apply more than 3.9 pt/A of Dual II Magnum per season. • *Do not* graze or feed treated forage for 30 days after application. • Adjust rates according to soil texture, organic matter, and application timing. • *Will not control emerged weeds.*
Equip 30% foramsulfuron + 2% iodosulfuron	32WDG	1.5 oz	**POST:** Apply when corn is in the V1 through V4 stage. **POST-directed:** Use drop nozzles when corn is greater than V4 and less than V8.	• Controls grasses and certain broadleaf weed species (Tables 12 and 14). • Registered for use on field corn; not recommended for use on corn grown for seed. • See Table 16 for compatability with soil insecticides. • Certain hybrids are sensitive to Equip. • *Do not* apply to corn exhibiting injury from previous herbicide applications. • *Do not* make more than one application or exceed 1.5 oz/A of Equip per season. • Must include an MSO or ESO in combination with a nitrogen fertilizer. • *Do not* apply within 70 days of harvesting corn grain or 45 days of harvesting corn forage. • *Do not* graze within 45 days of application. • Equip will not control ALS-resistant weed species.
Expert 1.74 lb *S*-metolachlor + 2.14 lb atrazine + 0.74 lb a.e. glyphosate	4.88SC	2.5 to 3.75 qt	**EPP:** Apply up to 30 days before planting. **PRE:** Apply before crop emergence. **POST:** Apply only to glyphosate-resistant hybrids up to 12 in. tall.	• Controls annual and perennial grasses and broadleaves. • Registered for use in field corn, popcorn, and sweet corn. • *Do not* graze or feed forage from treated areas for 60 days following application. • This product contains atrazine; follow the use limitations listed under atrazine. • Expert is a restricted use pesticide (RUP).

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Express SG tribenuron	50SG	0.25 to 0.5 oz	**EPP:** Apply at least 14 days before planting corn.	• Controls certain emerged winter annual broadleaf weed species. • Applications require the addition of a spray additive such as an NIS or a COC. • Tank-mixing with a broad-spectrum herbicide will expand burndown efficacy; select spray additives based on the additive limitations of the companion product. • *Do not* apply after corn planting.
FieldMaster 2.0 lb acetochlor + 1.5 lb atrazine + 0.56 lb a.e. glyphosate	4.06L	3.5 to 5 qt	**PRE:** Apply before crop emergence. **POST:** Apply only to glyphosate-resistant hybrids up to 11 in. tall.	• Controls sedges, annual grasses, broadleaf weeds, and existing vegetation (Tables 9, 12, and 14). • Registered for use in field corn, production seed corn, silage corn, and popcorn. • FieldMaster is a restricted use pesticide (RUP). • *Read* and *observe* all environmental precautions. • This product contains atrazine; follow the use limitations listed under atrazine. • *Do not* feed forage or graze treated areas within 60 days after application.
FulTime 2.4 lb acetochlor + 1.6 lb atrazine	4CS	2.5 to 5 qt	**EPP:** Apply up to 40 days before planting on medium- and fine-textured soils, or up to 14 days before planting on coarse-textured soils. **PPI:** Apply up to 14 days before planting. **PRE:** Apply after planting, before crop and weeds emerge. **POST:** Apply to corn up to 11 in. tall.	• Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14). • FulTime is a restricted use pesticide (RUP). • Registered for use on field corn, production seed corn, silage corn, popcorn, and sweet corn. • *Read* and *observe* all environmental precautions. • This product contains atrazine; follow the use limitations listed under atrazine. • Adjust rates according to soil texture, organic matter, and application timing.
glyphosate (many trade names) (See Table 8.)	Various formulations	See Table 8 for product rates.	**EPP Burndown:** Apply before planting to control existing vegetation.	• **POST applications:** *Use only on* ***glyphosate-resistant*** *corn hybrids.* • Controls grass and broadleaf weed species (Tables 9, 10, 12, 14, and 25).

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
glyphosate (cont.)			**PRE Burndown:** Apply after planting but before corn emerges to control existing vegetation. **POST:** Apply to ***glyphosate-resistant*** corn from emergence through the V8 stage or until corn reaches 30 in. tall, whichever is more restrictive. **POST-directed:** Apply to glyphosate-resistant corn from 30 to 48 in. tall.	• Application rates vary with weed size, application timing, and formulation. • Table 8 contains a list of glyphosate formulations. • Check individual labels for restrictions. • POST-directed applications in glyphosate-resistant hybrids: labeled only for certain hybrids.
Gramoxone Inteon paraquat	2S	2.0 to 4.0 pt 1.0 to 2.0 pt 1.2 to 2.0 pt	**EPP Burndown:** Apply before planting to control existing vegetation. **PRE Burndown:** Apply after planting but before corn emergence to control existing vegetation. **POST-directed:** Apply when corn is at least 10 in. tall. **Preharvest:** Apply at least 7 days prior to harvest.	• Controls existing vegetation (Tables 9 and 10). • Gramoxone Inteon is a restricted use pesticide (RUP). • *Do not* apply broadcast after crop emergence. • *Do not* use around gardens, schools, recreational parks, or playgrounds. • Always add an NIS or a COC to the spray mixture. • Adjust rates according to weed sizes. • *Preharvest:* Apply after black layer has formed at the base of the corn kernels and at least 7 days prior to harvest. • Use an NIS with preharvest applications.
Guardsman Max 1.7 lb dimethenamid-P + 3.3 lb atrazine	5L	2.5 to 4.6 pt	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 2 weeks before planting. **PRE:** Apply before crop and weeds emerge. **POST:** Apply to corn up to 12 in. tall.	• Controls annual grass and broadleaf weeds (Tables 12 and 14). • Registered for use on field corn, seed corn, sweet corn, and popcorn. • Guardsman Max is a restricted use pesticide (RUP). • Split applications of Guardsman Max are recommended if applied more than 30 days EPP. • An NIS or a COC may be used with POST-applied Guardsman Max. • This product contains atrazine; follow the use limitations listed under atrazine. • *Do not* graze or feed field corn forage within 60 days after application.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
G-Max Lite 2.25 lb dimethenamid-P + 2.75 lb atrazine	5L	2.0 to 3.5 pt	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 2 weeks before planting. **PRE:** Apply before crop and weeds emerge. **POST:** Apply to corn up to 12 in. tall.	• Adjust rates according to soil texture, organic matter, and cation-exchange capacity. • Controls annual grass and broadleaf weeds (Tables 12 and 14). • Registered for use on field corn, seed corn, sweet corn, and popcorn. • G-Max Lite is a restricted use pesticide (RUP). • G-Max Lite contains less atrazine than Guardsman Max. • *See "Remarks and limitations" for Guardsman Max.*
Halex GT 2.09 lb S-metolachlor + 2.09 lb glyphosate + 0.209 lb mesotrione	4.38CS	3.6 to 4.0 pt	**POST:** Apply to glyphosate-resistant corn from emergence to 30 inches tall or the 8-leaf stage.	• Controls grass and broadleaf weed species (Tables 12 and 14). • Apply only to corn hybrids resistant to glyphosate. • For optimal results, apply before grass and broadleaf weeds exceed 4 in. tall. • Applications must include an NIS and an AMS. • *Do not* tank-mix with emulsifiable concentrate grass herbicides or organophosphate or carbamate insecticides. • *Do not* apply to ground that has been or will be treated in the same season with Callisto.
Harmony GT XP thifensulfuron	75DF	0.083 oz	**POST:** Apply to corn up to 16 in. tall or through the V5 stage, whichever is more restrictive.	• Controls some annual broadleaf weeds. • *Do not* apply to fields treated with Counter insecticide. • Applications must include an NIS or a COC in addition to an ammonium nitrogen fertilizer. • *Do not* apply to sweet corn, popcorn, or field corn grown for seed.
Harmony SG thifensulfuron	50DF	0.125 oz		
Harmony Extra XP 50% thifensulfuron + 25% tribenuron	75DF	0.3 to 0.6 oz	**EPP:** Apply at least 14 days before planting corn.	• Controls certain emerged winter annual broadleaf weed species. • Tank-mixing with a broad-spectrum herbicide expands burndown efficacy; select spray additive limitations of the companion product. • *Do not* apply after corn planting.
Harmony Extra SG 33.33% thifensulfuron + 16.67% tribenuron	50SG	0.45 to 0.9 oz		

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Harness acetochlor	7EC	1.25 to 2.75 pt	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply to the surface at planting, before crop and weeds emerge, and within 5 days after the last preplant tillage operation. **POST:** Apply to corn up to 11 in. tall.	• Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12). • Harness is a restricted use pesticide (RUP). • Registered for use on field corn, production seed corn, silage corn, and popcorn. • *Read* and *observe* all environmental precautions. • Adjust rates according to soil texture and organic matter. • *Will not control emerged weeds.*
Harness Xtra 5.6L 3.1 lb acetochlor + 2.5 lb atrazine	5.6L	1.4 to 3 qt	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply to the surface at planting, before crop and weeds emerge, and within 5 days after the last preplant tillage operation. **POST:** Apply to corn up to 11 in. tall.	• Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14). • Harness Xtra 5.6L is a restricted use pesticide (RUP). • Registered for use on field corn, production seed corn, silage corn, and popcorn. • *Read* and *observe* all environmental precautions. • This product contains atrazine; follow the use limitations listed under atrazine. • Adjust rates according to soil texture and organic matter. • *Do not* feed forage or graze treated areas within 60 days after application.
Harness Xtra 4.3 lb acetochlor + 1.7 lb atrazine	6L	1.8 to 2.3 qt	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply to the surface at plantng, before crop and weeds emerge, and within 5 days after the last preplant tillage operation. **POST:** Apply to corn up to 11 in. tall.	• Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14). • Harness Xtra is a restricted use pesticide (RUP). • Registered for use on field corn, production seed corn, silage corn, and popcorn. • *Read* and *observe* all environmental precautions. • Harness Xtra 6L contains less atrazine than Harness Xtra 5.6L. • This product contains atrazine; follow the use limitations listed under atrazine. • Adjust rates according to soil texture and organic matter. • *Do not* feed forage or graze treated areas within 60 days after application.

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Hornet WDG 18.5% flumetsulam + 50% a.e. clopyralid	68.5WDG	4 to 5 oz 4 to 5 oz 4 to 5 oz 4 to 5 oz 2 to 5 oz	**EPP:** Apply up to 30 days before planting. **PPI:** Apply up to 30 days before planting. **PRE:** Apply at or just after planting but before crop and weeds emerge. **SPIKE:** Apply to corn from emergence until 2 in. tall and before the first leaf is unfurled. **POST:** Apply to corn from spike until 20 in. tall or the V6 stage, whichever is more restrictive. **POST-directed:** Apply to corn up to 36 in. tall.	• Controls broadleaf weeds (Table 14). • Registered for use on field corn. • **Soil applications:** Corn should be planted at least 1.5 in. deep. • **Soil applications:** *Do not* apply to areas with soil pH greater than 7.8. • **Soil applications:** *Do not* apply to peat or muck soils or to soil with more than 5% organic matter and pH below 5.9. • **Soil applications:** Use of Hornet on soils with less than 1.5% organic matter may result in unacceptable injury. • **Soil applications:** See Table 16 for compatibility with soil insecticides. • *Do not* exceed 6 oz/A of Hornet WDG per season. • *Do not* harvest field corn within 85 days after application. • Adjust application rates according to soil texture and organic matter (soil-applied) and weed size (POST). • **POST applications:** All applications must include an NIS, a COC, or an MSO; under dry conditions, add an ammonium nitrogen fertilizer. • **POST applications:** *Do not* tank-mix with Laddok or Lightning due to risk of crop injury.
Impact topramezone	2.8SC	0.75 fl oz	**POST:** Apply up to 45 days before harvest.	• Controls annual grasses and broadleaf weeds (Tables 12 and 14). • Can be applied to field corn, seed corn, popcorn, and sweet corn. • Tank-mixing atrazine with Impact is recommended for improved weed control. • Applications must include either an MSO or a COC with an ammonium fertilizer. • *Do not* exceed 0.75 fl oz per acre per season. • A reduced rate of 0.5 fl oz may be applied north of Interstate 80. • Impact may be applied sequentially with mesotrione-containing products only where corn will be planted the following season.

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate / A	Application timings	Remarks and limitations
Keystone 3.0 lb acetochlor + 2.25 lb atrazine	5.25L	2.2 to 3.4 qt	**EPP:** Apply up to 30 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply before crop and weeds emerge. **POST:** Apply to corn up to 11 in. tall.	Controls sedges, annual grasses and broadleaf weeds (Tables 12 and 14). • Registered for use on field corn, production seed corn, silage corn, popcorn, and sweet corn. • Keystone is a restricted use pesticide (RUP). • Keystone may be tank-mixed with a number of herbicides to improve control of certain weed species. • This product contains atrazine; follow the use limitations listed under atrazine. • *Do not* apply POST using nitrogen as a carrier. • *Do not* feed forage or graze treated areas within 60 days after application.
Keystone LA 4.0 lb acetochlor + 1.5 lb atrazine	5.5 L	1.6 to 3 qt	**EPP:** Apply up to 30 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply before crop and weeds emerge. **POST:** Apply to corn up to 11 in. tall.	• Controls sedges, annual grasses and broadleaf weeds (Tables 12 and 14). • Registered for use on field corn, production seed corn, silage corn, popcorn, and sweet corn. • Keystone LA is a restricted use product (RUP). • Keystone LA contains less atrazine than Keystone. • This product contains atrazine; follow the use limitations listed under atrazine. • *Do not* feed forage or graze treated areas within 60 days after application.
Laddok S-12 2.5 lb bentazon + 2.5 lb atrazine	5L	1.33 to 2.33 pt	**POST:** Apply to corn up to 12 in. tall.	• Controls broadleaf weeds and sedges (Table 14). • Registered for use on field corn, production seed corn, silage corn, sweet corn, and popcorn. • Laddok is a restricted use pesticide (RUP). • *Do not* make more than one application of Laddok per season. • This product contains atrazine; follow the use limitations listed under atrazine. • An adjuvant is required for consistent weed control.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Lexar 1.74 lb *S*-metolachlor + 0.224 lb mesotrione + 1.74 lb atrazine	3.7L	2.25 to 3.5 qt	**EPP:** Apply up to 14 days before planting. **PRE:** Apply before crop and weeds emerge. **POST:** Apply to field corn up to 12 in. tall.	• Controls annual grasses and broadleaves. • Registered for use on field corn, production seed corn, silage corn, yellow popcorn, and sweet corn. • Lexar is a restricted use pesticide (RUP). • *Do not* harvest forage, grain, or stover within 60 days after the last application. • *Do not* apply other mesotrione-containing products to ground that has been treated with Lexar in the same season. • *Do not* make a POST application of an organophosphate or carbamate insecticide within 7 days before or after applying Lexar. • This product contains atrazine; follow the use limitations listed under atrazine.
Liberty glufosinate	1.67S	28 to 34 fl oz	**POST:** Apply to corn up to 24 in. tall or the V7 stage, whichever is more restrictive. **POST-directed:** Apply to corn from 24 to 36 in. tall.	• *Use only on* ***Liberty Link*** *hybrids.* • Controls annual grass and broadleaf weed species (Tables 12 and 14). • *Do not* make more than two applications per growing season, or exceed 62 oz/A of Liberty per growing season. • *Do not* harvest for forage within 60 days of application. • *Do not* harvest for grain or fodder within 70 days of application. • *Do not* add any surfactants or crop oils. • Applications must include an AMS fertilizer.
Lightning 52.5% imazethapyr + 17.5% imazapyr	70DG	1.28 oz	**POST:** Apply to corn up to 20 in. tall or the V6 stage, whichever is more restrictive. **POST-directed:** Apply to corn from 20 in. tall to 45 days prior to harvest.	• *Use only on* ***Clearfield*** *hybrids.* • Controls grass and broadleaf weed species (Tables 12 and 14). • *Do not* make more than one application per growing season. • *Do not* harvest for grain, forage, fodder, or silage within 45 days after application; *do not* graze within 45 days after application. • See Table 16 for compatibility with soil insecticides. • An NIS or a COC in combination with a nitrogen-based fertilizer must be included. • Lightning will not control ALS-resistant weed species.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Lumax 2.68 lb S-metolachlor + 0.268 lb mesotrione + 1.0 lb atrazine	3.95L	2.0 to 3.0 qt	**EPP:** Apply up to 14 days before planting. **PRE:** Apply before crop and weeds emerge. **EPOST:** Apply before field corn is more than 12 in. tall.	• Controls annual grass and broadleaf weeds (Tables 12 and 14). • Registered for use on field corn, production seed corn, silage corn, yellow popcorn, and sweet corn. • Lumax is a restricted use pesticide (RUP). • Additional atrazine may be added to improve control of certain broadleaf weed species. • This product contains atrazine; follow the use limitations listed under atrazine. • *Do not* apply more than 3 qt/A of Lumax per season. • An NIS may be used with POST-applied Lumax. • *Do not* harvest forage, grain, or stover within 60 days after application; *do not* graze or feed forage from treated areas within 45 days after application. • *Do not* apply other mesotrione-containing products to ground that has been treated with Lumax in the same season. • *Do not* apply POST tank-mixed with organophosphate or carbamate insecticides. • *Do not* apply POST using nitrogen as a carrier.
Marksman 1.1 lb dicamba + 2.1 lb atrazine	3.2L	2 to 3.5 pt	**PRE:** May be applied after planting and prior to corn emergence. **EPOST:** Apply to corn between emergence and the 5-leaf stage or until corn is 8 in. tall, whichever is more restrictive.	• Controls broadleaf weeds (Table 14). • Marksman is a restricted use pesticide (RUP). • Registered for use on field corn, production seed corn, silage corn, and popcorn. • *Do not* harvest treated plants or graze for feed before the ensilage (milk) stage. • *Do not* make more than two applications per season or exceed 5.25 pt/A of Marksman per season. •*Do not* apply PRE to coarse-textured soils or to any soils with less than 2.5% organic matter. *(continues)*

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Marksman (cont.)				• This product contains atrazine; follow the use limitations listed under atrazine. • This product contains dicamba; take precautions to avoid drift onto desirable legumes and broadleaf crops. • Adjust rates according to soil texture and organic matter.
Micro-Tech alachlor	4CS	2 to 3.5 qt	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 7 days before planting. **PRE:** Apply to the surface at planting, before crop and weeds emerge, and within 5 days after the last preplant tillage operation. **POST:** Apply before corn is more than 5 in. tall.	• Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12). • Micro-Tech is a restricted use pesticide (RUP). • Registered for use on all types of corn. • *Read* and *observe* all environmental precautions. • *Do not* exceed a total of 4 qt/A of Micro-Tech per year. • Adjust rates according to soil texture and organic matter. • *Will not control emerged weeds.*
NorthStar 7.5% primisulfuron + 39.9% dicamba	47.4WDG	5 oz	**POST:** Apply to corn from 4 to 20 in. tall (from the V2 to V6 stage). **POST-directed:** Apply to corn from 20 to 36 in. tall.	• Controls annual broadleaf and certain grass weeds (Tables 12 and 14). • Registered for use on field corn, seed corn, popcorn, and silage corn. • *Do not* apply to corn less than 4 in. tall. • See Table 16 for compatibility with soil insecticides. • *Do not* graze or feed forage from treated areas within 30 days after application. • *Do not* harvest for silage within 45 days after application. • *Do not* harvest for grain within 60 days after application. •*Do not* exceed one application or 5 oz/A of NorthStar per season. • All applications of NorthStar should be made no later than 15 days before tassel emergence. • This product contains dicamba; take precautions to avoid drift onto desirable legumes and broadleaf crops. • Apply with a COC or an NIS and a nitrogen source.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Option foramsulfuron	35WDG	1.5 to 1.75 oz	**POST:** Apply when corn is in the V1 through V6 growth stage. **POST-directed:** Apply to corn greater than V6 and less than V8.	• Controls grasses and certain broadleaf weed species (Tables 12 and 14). • Registered for use on field corn. Consult seed company before applying on corn grown for seed. • See Table 16 for compatibility with soil insecticides. • Certain hybrids are sensitive to Option. • *Do not* apply to corn that already exhibits herbicide injury from a previous herbicide application. • *Do not* apply within 70 days of harvesting corn grain or 45 days of harvesting corn forage. • *Do not* graze within 45 days of application. • *Do not* exceed two applications or 3.5 oz/A of Option per season. • Must include an MSO or ESO in combination with a nitrogen fertilizer. • Option will not control ALS-resistant weed species.
Outlook dimethenamid-P	6EC	8 to 21 fl oz	**Fall:** Apply north of Illinois Route 136 after October 1. **EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 2 weeks before planting. **PRE:** Apply before crop and weeds emerge. **POST:** May be applied to corn up to 12 in. tall. **Layby:** Apply to corn from 12 to 36 in. tall.	• Controls annual grass and certain small-seeded broadleaf weeds (Table 12). • Registered for use on field corn, popcorn, seed corn, and sweet corn. • *Do not* apply more than 21 fl oz/A of Outlook per season. • *Do not* graze or feed forage from treated areas within 40 days after application. • Adjust rates according to soil texture, organic matter, and cation-exchange capacity. • *Will not control emerged weeds.*

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate / A	Application timings	Remarks and limitations
Permit halosulfuron	75WG	0.67 to 1.33 oz	**POST:** Can be applied to field corn from spike through layby stage.	• Controls sedges and certain annual broadleaf weeds (Tables 12 and 14). • Registered for use on field corn, field corn grown for seed, sweet corn, and popcorn. • *Do not* exceed two applications or 2.66 oz/A of Permit per season. • *Do not* harvest for forage or silage within 30 days of application; *do not* graze within 30 days of application. • An NIS or a COC must be used. • Permit will not control ALS-resistant weed species.
Princep simazine	4L 90WDG	2 to 8 pt 1.1 to 4.4 lb	**Fall Burndown:** Apply after harvest but before winter annual weeds emerge and the ground freezes. **EPP:** Apply up to 2 weeks before planting. **PRE:** Apply before crop and weeds emerge.	• Controls annual grass and broadleaf weeds (Tables 12 and 14). • Registered for use on corn. • *Do not* exceed 2 qt/A of Princep 4L if Princep is used in the fall. • *Do not* apply more than 8 pt/A or 4.4 lb/A/year. • *Do not* graze treated areas.
Prowl or **Pendimax**	3.3EC	1.8 to 4.8 pt	**PRE:** Apply after planting but before crop and weeds emerge.	• Controls annual grasses and certain small-seeded broadleaf weeds (Table 12). • Registered for use on field corn, sweet corn, seed corn, and popcorn. • *Do not* apply PP or PPI. • Plant corn at least 1.5 in. deep. • Corn seed must be completely covered with soil. • *Do not* exceed the maximum labeled rate for any soil type. • *Do not* graze or feed forage from treated areas within 12 to 21 days of application (depends on formulation). • Adjust rates according to soil texture and organic matter. • *Will not control emerged weeds.*
Prowl H_2O pendimethalin	3.8 CS	2.0 to 4.0 pt	**POST:** Apply to field corn up to 30 in. tall or the V8 stage, whichever is more restrictive.	

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Pursuit imazethapyr	70DG	1.44 oz	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 45 days before planting. **PRE:** Apply before crop and weeds emerge. **POST:** Apply after crop and weeds emerge.	• *Use only on* ***Clearfield*** *hybrids.* • Controls grass and broadleaf weed species (Tables 19, 21, and 22). • *Do not* make more than one application per growing season. • *Do not* harvest for grain, forage, fodder, or silage within 45 days after application; *do not* graze within 45 days after application. • Check label for compatibility with soil insecticides. • Include an adjuvant and a fertilizer solution for POST applications. • Pursuit will not control ALS-resistant weed species.
Pursuit Plus 0.2 lb imazethapyr + 2.7 lb pendimethalin	2.9EC	2.5 pt	**PRE:** Apply after planting but before crop and weeds emerge. **POST:** Apply after crop and weeds emerge.	• *Use only on* ***Clearfield*** *hybrids.* • Controls grass and broadleaf weed species (Tables 19, 21, and 22). • *Do not* apply PP or PPI. • Plant corn at least 1.5 in. deep. • Corn seed must be completely covered with soil. • *Do not* harvest for grain, forage, fodder, or silage within 45 days after application; *do not* graze within 45 days after application. • Check label for compatibility with soil insecticides. • POST applications require an NIS and a fertilizer solution.
Python WDG flumetsulam	80WDG	0.8 to 1.33 oz	**EPP:** Apply up to 30 days before planting. **PPI:** Apply up to 30 days before planting. **PRE:** Apply at or just after planting but prior to weed emergence.	• Controls broadleaf weeds (Table 14). • *Do not* apply to sweet corn or popcorn. • *Do not* exceed 1.4 oz/A of Python WDG per growing season. • An interval of 85 days is required between application of Python WDG and harvest. • *Do not* apply to soils with pH greater than 7.8. • *Do not* use Python WDG on soils with less than 1.5% organic matter, or unacceptable injury may occur. • See Table 16 for compatibility with soil insecticides. • Python will not control ALS-resistant weed species.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Radius 3.57 lb flufenacet + 0.43 lb isoxaflutole	4SC	7 to 28 fl oz	**EPP:** Apply up to 21 days before planting. **PPI:** Apply up to 21 days before planting. **PRE:** Apply before crop and weeds emerge.	• Controls annual broadleaf and grass weeds (Tables 12 and 14). • *Do not* use on popcorn, sweet corn, or corn grown for seed. • Radius is a restricted use pesticide (RUP). • *Do not* make more than one application of Radius per season. • Read and observe all environmental precautions. • Radius has some burndown activity; apply with a COC or an MSO. • *Do not* apply to very sandy soils. • Adjust rates according to soil texture, organic matter, and application timing.
Resolve rimsulfuron	25WDG	0.5 to 2 oz 0.5 to 2 oz	**PRE:** Apply before corn emerges. **POST:** Do not apply to corn taller than 12 in. or exhibiting 6 or more collars.	• Controls certain grass and broadleaf weed species. • *Do not* apply to field corn grown for seed, popcorn, or sweet corn. • Applications must include an NIS or a COC with an ammonium fertilizer. • *Do not* apply preemergence to coarse-textured soils with less than 1% organic matter. • *Do not* tank-mix with Basagran, Laddok, or foliar-applied organophosphate insecticides.
Resource flumiclorac	0.86EC	4 to 8 fl oz	**POST:** Apply to corn between the 2-leaf and 10-leaf stages. **POST-directed:** Apply after corn has reached sufficient height for the spray to be directed beneath the corn leaves.	• Controls velvetleaf and certain other broadleaf weeds (Table 14). • Registered for use on field corn. • *Do not* apply more than 6 fl oz/A in a single broadcast application or more than a total of 8 fl oz/A of Resource per season. • *Do not* graze animals on green forage or use as feed until at least 28 days after application. • Applications must include a COC or an MSO; nitrogen fertilizer also can be added.
Sencor metribuzin	75DF	2 to 5.33 oz 2 to 4 oz 2 to 4 oz	**EPP:** Apply from 10 to 30 days before planting. **PRE:** Apply from 0 to 9 days before planting. **POST:** Apply from crop emergence until just prior to tasseling.	• Controls certain grasses and broadleaf weeds (Table 21). • **Soil applications:** *Do not* apply on coarse-textured soils with less than 1.5% organic matter. • **Soil applications:** *Do not* apply more than 4 oz/A of Sencor on soils with less than 2% organic matter. • **Soil applications:** *Do not* apply on soils having a pH of 7.0 or greater.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Sencor (cont.)				• **Soil applications:** Sencor can be used on hybrid seed-corn production fields if both inbred parents are known to have tolerance to Sencor. • **POST applications:** *Do not* use COCs or any adjuvants containing vegetable or petroleum oils. • **POST applications:** *Do not* use on sweet corn, popcorn, white corn, or corn grown for seed. • **POST applications:** *Do not* apply when field corn is under stress. • **POST applications:** *Do not* use on sand, loamy sand, or sandy loam soils that have less than 0.5% organic matter. • *Do not* apply more than 5.33 oz/A of Sencor per growing season. • *Do not* graze or harvest for silage or grain within 28 days after application.
Shotgun 2.25 lb atrazine + 1.0 lb a.e 2,4-D	3.25L	2 to 3 pt	**EPP:** Apply 7 to 14 days before planting. **PRE:** Apply 5 to 7 days after planting but before corn emergence. **EPOST:** Apply to corn from spike to the 4-leaf stage but before corn is 8 in. tall. **POST-directed:** Apply to corn from 8 to 12 in. tall or the 5-leaf stage, whichever is more restrictive.	• Controls broadleaf weeds (Table 14). • Shotgun is a restricted use pesticide (RUP). • Registered for use on field corn. • *Do not* make PP or PRE applications to medium- and fine-textured soils with less than 1% organic matter or to coarse-textured soils with less than 2% organic matter. • *Do not* make PP or PRE applications unless corn is planted at least 1.5 in. deep. • *Do not* make POST applications of Shotgun within 3 weeks of PP or PRE applications. • This product contains atrazine; follow the use limitations listed under atrazine. • This product contains 2,4-D; take precautions to avoid drift onto desirable legumes and broadleaf crops. • Adjust rates according to soil texture and organic matter.

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Spirit 42.8% primisulfuron + 14.2% prosulfuron	57WDG	1 oz	**POST:** Apply to corn from 4 to 20 in. tall or the V6 stage, whichever is more restrictive. **POST-directed:** Drop nozzles may be used on corn from 20 to 24 in. tall.	• Controls annual broadleaf and certain grass weeds (Tables 12 and 14). • *Do not* apply to sweet corn or ornamental corn. • *Do not* graze or feed forage from treated areas within 30 days after application. • *Do not* harvest for silage within 40 days after application. • *Do not* harvest for grain within 60 days after application. • Apply with a COC or an NIS and a nitrogen source. • Spirit will not control ALS-resistant weed species.
Starane fluroxypyr	1.5 EC	0.67 pt	**POST:** Apply through the V5 growth stage.	• Controls certain annual and perennial broadleaf species. • Do not make more than two applications or apply more than 1.33 pt/A/season. • Registered for use in field corn and sweet corn. • *Do not* graze or harvest forage from treated areas within 47 days of application. • *Do not* apply less than 90 days before grain harvest.
Status 40% dicamba + 16% diflufenzopyr	56WDG	5 to 10 oz	**POST:** Apply to corn between 4 and 36 in. tall, or between V2 and V10.	• Controls certain annual and perennial broadleaf weeds (Tables 14 and 25). • Registered for use on field corn, silage corn, or corn grown for seed. • Applications must include an NIS or a COC with an ammonium fertilizer. • Allow a minimum of 15 days between sequential applications. • *Do not* apply if corn is more than 36 in. tall, or V10 stage, or 15 days before tassel emergence, whichever comes first.
Steadfast 50% nicosulfuron + 25% rimsulfuron	75WDG	0.75 oz	**POST:** Apply to corn up to 20 in. tall or through the V6 stage, whichever is more restrictive.	• Controls grasses and certain broadleaf weed species (Tables 12 and 14). • Registered for use in field corn. • *Do not* apply to field corn grown for seed, popcorn, or sweet corn. • See Table 16 for compatibility with soil insecticides.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Steadfast (cont.)				• Must include a COC or an NIS; the addition of a nitrogen source is also required unless prohibited on tank-mix partner label. • *Do not* apply more than 0.75 oz/A of Steadfast per year. • *Do not* tank-mix with Basagran, Laddok, or 2,4-D. • *Do not* tank-mix with other ALS-inhibiting herbicides unless recommended. • *Do not* graze or feed forage, hay, or straw within 30 days of applying Steadfast. • Steadfast will not control ALS-resistant weed species.
Steadfast ATZ 2.7% nicosulfuron + 1.3% rimsulfuron + 85.3% atrazine	89.3WDG	14 oz	**POST:** Apply to corn up to 12 in. tall or through the V6 stage, whichever is more restrictive.	• Controls annual grass and broadleaf weeds (Tables 12 and 14). • Registered for use in field corn. • This product contains atrazine; follow the use limitations listed under atrazine. • *Do not* tank-mix with Basagran, Laddok S-12, or 2,4-D. • Steadfast ATZ is a restricted use pesticide (RUP). • Must include a COC or an NIS; the addition of an ammonium nitrogen is also required. • *Do not* apply to field corn grown for seed, popcorn, or sweet corn. • *Do not* tank-mix with other ALS-inhibiting herbicides unless recommended. • *Do not* graze or feed forage, hay, or straw within 60 days of applying Steadfast ATZ.
Stinger clopyralid	3S	0.25 to 0.67 pt	**POST:** Apply to corn from emergence up to 24 in. tall.	• Controls Canada thistle and other broadleaf weeds (Table 14). • Registered for use on field corn, production seed corn, popcorn, and sweet corn. • *Do not* exceed 0.25 lb a.i. of clopyralid/A or 0.67 pt of Stinger/A/year. • Use of a spray adjuvant is not necessary but may increase control of certain broadleaf weeds.

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate / A	Application timings	Remarks and limitations
SureStart 3.75 lb acetochlor + 0.29 lb a.e. clopyralid + 0.12 lb flumetsulam	4.16SE	1.5 to 2 pt	**Fall:** Apply after October 15 when 4-in. soil temperature is less than 50°F but before ground freezes. **EPP:** Apply up to 30 days before planting corn. **PPI:** Apply up to 14 days before planting corn. **PRE:** Apply before or after planting. **POST:** Apply POST to corn up to 11 in. tall.	• Provides early-season control of certain annual grass and broadleaf weed species (Tables 12 and 14). • SureStart is for use only on herbicide-resistant field corn and silage corn. • Corn seed should be planted at least 1.5 in. deep. • POST applications will not control emerged grass weeds; a tank-mix partner will be needed for broad-spectrum control. • *Do not* apply to soils with a pH greater than 7.8, or those with less than 1.5% organic matter.
Surpass acetochlor	6.4EC	1.5 to 3.75 pt	**Fall:** Apply north of Illinois Route 136 after October 15. **EPP:** Apply up to 30 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply after planting but before crop emergence. **POST:** Apply until corn reaches 11 in. tall.	• Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12). • Surpass is a restricted use pesticide (RUP). • Registered for use on field corn, production seed corn, silage corn, popcorn, and sweet corn. • *Read* and *observe* all environmental precautions. • *Do not* apply more than 3.75 pt/A of Surpass per season. • Adjust rates according to soil texture and organic matter. • *Will not control emerged weeds.*
TopNotch acetochlor	3.2CS	2 to 3 qt	**Fall:** Apply north of Illinois Route 136 after October 15. **EPP:** Apply up to 40 days before planting. **PPI:** Apply up to 10 days before planting. **PRE:** Apply after planting but before crop emergence. **POST:** Apply to corn up to 11 in. tall.	• Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12). • TopNotch is a restricted use pesticide (RUP). • Registered for use on field corn, production seed corn, silage corn, popcorn, and sweet corn. • *Read* and *observe* all environmental precautions. • Adjust rates according to soil texture and organic matter. • *Will not control emerged weeds.*

Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate / A	Application timings	Remarks and limitations
Yukon 12.5% halosulfuron + 55% dicamba	67.5WSG	4 to 8 oz	**POST:** Apply to corn from spike up to 36 in. tall. **POST-directed:** Drop nozzles may be used on corn from spike to 36 in. tall.	• Controls broadleaf weeds and sedges (Tables 12 and 14). • Registered for use on field corn and field corn grown for seed. • *Do not* make more than two applications of Yukon per year. • *Do not* exceed 8 oz/A of Yukon per year. • Allow at least 2 weeks between applications. • *Do not* graze or harvest for feed until the crop reaches the ensilage (milk) stage, at least 30 days after application. • This product contains dicamba; take precautions to avoid drift onto desirable legumes and broadleaf crops. • The use of an NIS is required, but it can be replaced with a COC; a nitrogen source is recommended.

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

Table 2. Sorghum herbicides (Read and follow label directions before using product.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
2,4-D Amine (many trade names)	3.8 lb a.e. (many)	1 pt	**POST:** Apply to sorghum from 6 to 8 in. tall. **POST-directed:** Apply to sorghum from 8 to 15 in. tall.	• Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25). • Registered for use on grain sorghum (milo). • *Do not* treat during the boot stage, flowering, or dough stage. • *Do not* forage for feed fodder for 7 days after application. • Spray particles can drift and cause injury to susceptible plants.
2,4-D Ester (many trade names)	3.8 lb a.e. (many)	0.5 to 1 pt	**POST:** Apply to sorghum from 5 to 8 in. tall. **POST-directed:** Apply to sorghum from 8 to 15 in. tall.	• Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25). • Registered for use on grain sorghum (milo). • Use 0.75 to 1 pt/A for control of perennial weeds. • 2,4-D ester can volatilize if temperatures exceed 85°F. • *See "Remarks and limitations" for 2,4-D Amine.*
AAtrex, Atrazine atrazine	4L 90DF	0.5 to 2.0 lb a.i.	**EPP:** Apply up to 45 days before planting, except on coarse-textured soils. **PPI:** Apply up to 14 days before planting. **PRE:** Apply before crop and weeds emerge. **POST:** Apply to sorghum up to 12 in. tall.	• Controls annual broadleaf and certain grass weeds (Table 14). • Registered for use on sorghum and sorghum–sudan grass hybrids (grain and forage types). • Atrazine is a restricted use pesticide (RUP). • *Do not* apply more than 2.5 lb a.i. atrazine/A in a calendar year. • *Do not* apply more than 1.6 lb a.i. atrazine/A/application on highly erodible soils with less than 30% residue cover. • *Do not* apply more than 2.0 lb a.i. atrazine/A/application on soils that are not highly erodible or on highly erodible soils with at least 30% residue cover. • Risk of carryover is greater on soils with pH greater than 7.2. • POST applications should include a COC.

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant.

Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Aim carfentrazone	1.9EW	0.5 fl oz	**Preplant Burndown:** Apply from prior to planting through sorghum emergence. **POST:** Apply to sorghum up to the 6-leaf stage.	• Controls some annual broadleaf weeds (Table 14). • Registered for use on grain and forage sorghum. • For broad-spectrum weed control, Aim will need to be tank-mixed. • *Do not* apply more than 1.0 fl oz/A of Aim EW per season. • The use of drop nozzles is recommended for POST applications to sorghum grown for seed. • Must include an NIS. • The use of a COC for POST applications is *not* recommended.
Banvel dicamba	4L	0.5 pt	**Preplant Burndown:** Apply to actively growing weeds at least 15 days prior to planting. **POST:** Apply to sorghum from spike to 8 in. tall. **POST-directed:** Apply to sorghum from 8 to 15 in. tall.	• Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25). • Registered for use on sorghum (milo). • Applications during periods of rapid growth may result in temporary leaning of plants or rolling of leaves. • *Do not* graze or feed treated sorghum forage or silage prior to mature grain stage. • Take precautions to avoid drift onto desirable legumes and broadleaf crops. • *Do not* make more than one application per growing season.
Basagran bentazon	4S	1 to 2 pt	**POST:** Apply to actively growing weeds within the size limits listed on the label.	• Controls broadleaf weeds and sedges (Table 14). • Registered for use on grain and forage sorghum. • *Do not* graze treated sorghum for at least 12 days after application. • *Do not* apply more than 2 pt/A of Basagran per year. • *Do not* apply to sorghum that is heading or blooming. • Include a COC and/or a spray-grade nitrogen source.

Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate / A	Application timings	Remarks and limitations
Bicep II Magnum 2.4 lb *S*-metolachlor + 3.1 lb atrazine	5.5L	1.6 to 2.58 qt	**EPP:** Apply up to 45 days before planting, except on any coarse soil or on medium soils with less than 1% organic matter. **PPI:** Apply up to 14 days before planting, except on any coarse soil or on medium soils with less than 1% organic matter. **PRE:** Apply to the surface at planting but before crop and weeds emerge, except on any coarse soil or on medium soils with less than 1% organic matter.	• Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14). • *Sorghum seed must be treated with a safener (Concep).* • Bicep II Magnum is a restricted use pesticide (RUP). • Registered for use on grain and forage sorghum. • This product contains atrazine; follow the use limitations listed under atrazine. • This product contains *S*-metolachlor; follow the use limitations listed under Dual II Magnum. • *Do not* graze or feed forage from treated areas for 60 days following application. • Adjust rates according to soil texture, organic matter, and application timing.
Bicep Lite II Magnum 3.33 lb *S*-metolachlor + 2.67 lb atrazine	6L	1.1 to 1.9 qt	**EPP:** Apply up to 45 days before planting, except on any coarse soil or on medium soils with less than 1% organic matter. **PP:** Apply up to 14 days before planting, except on any coarse soil or on medium soils with less than 1% organic matter. **PRE:** Apply to the surface at planting but before weeds and crop emerge, except on any coarse soil or on medium soils with less than 1% organic matter.	• Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14). • *Sorghum seed must be treated with a safener (Concep).* • Bicep Lite II Magnum is a restricted use pesticide (RUP). • Bicep Lite II Magnum contains less atrazine than Bicep II Magnum. • *See "Remarks and limitations" for Bicep II Magnum.*

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant.

Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Buctril bromoxynil	2EC	1 to 1.5 pt 1 to 1.5 pt	**PRE:** Apply from before planting until just prior to emergence to control existing vegetation. **POST:** Apply to sorghum from the 3-leaf stage until prior to the preboot stage.	• Controls certain annual broadleaf weeds (Table 14). • Registered for use on sorghum (grain and forage). • *Do not* harvest for feed or fodder and *do not* graze within 45 days after application. • *Do not* exceed 2 pt/A of Buctril per season. • *Do not* apply the 2 pt/A rate of Buctril to sorghum. • Use of an adjuvant or liquid fertilizer may cause excessive leaf burn.
Buctril + atrazine 1.0 lb bromoxynil + 2.0 lb atrazine	3L	1.5 to 3 pt 1.5 to 3 pt	**PRE:** Apply from before planting until just prior to emergence to control existing vegetation. **POST:** Apply to sorghum from the 3-leaf stage until prior to the preboot stage or 12 in. tall, whichever is more restrictive.	• Controls certain annual broadleaf weeds (Table 14). • Buctril + atrazine is a restricted use pesticide (RUP). • Registered for use on sorghum (grain and forage). • *Do not* harvest for feed or fodder and *do not* graze within 45 days after application. • *Do not* exceed 4 pt/A of Buctril + atrazine per season. • *Do not* use on sandy or sandy loam soils, or excessive crop injury may occur. • This product contains atrazine; follow the use limitations listed under atrazine. • Use of an adjuvant or liquid fertilizer may cause excessive leaf burn.
Bullet 2.5 lb alachlor + 1.5 lb atrazine	4ME	2.5 to 4.0 qt	**PPI:** Apply up to 7 days before planting. **PRE:** Apply after planting but before crop and weeds emerge.	• Controls annual grass and broadleaf weeds (Tables 12 and 14). • *Sorghum seed must be treated with a safener.* • Bullet is a restricted use pesticide (RUP). • Registered for use on grain sorghum (milo). • This product contains atrazine; follow the use limitations listed under atrazine. • *Do not* make more than two applications of Bullet per year or exceed 6.4 qt/A of Bullet per year. • *Do not* graze or harvest forage for 70 days following application. • Adjust rates according to soil texture and organic matter.

Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Clarity dicamba	4L	0.5 pt	**Preplant Burndown:** Apply to actively growing weeds at least 15 days prior to planting. **POST:** Apply to sorghum from spike to 8 in. tall. **POST-directed:** Apply to sorghum from 8 to 15 in. tall.	• Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25). • Registered for use on sorghum (milo). • Applications during periods of rapid growth may result in temporary leaning of plants or rolling of leaves. • *Do not* graze or feed treated sorghum forage or silage prior to mature grain stage. • Take precautions to avoid drift onto desirable legumes and broadleaf crops.
Dual II Magnum *S*-metolachlor	7.64EC	1 to 1.67 pt	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply before crop and weeds emerge.	• Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12). • *Sorghum seed must be treated with a safener (Concep).* • Registered for use on grain and forage sorghum. • *Do not* make more than one application of Dual II Magnum per season. • *Do not* graze or feed treated forage for 30 days after application. • Adjust rates according to soil texture, organic matter, and application timing.
Expert 1.74 lb *S*-metolachlor + 2.14 lb atrazine + 0.74 lb a.e. glyphosate	4.88SC	2.5 to 3.75 qt	**EPP:** Apply up to 30 days before planting. **PRE:** Apply before crop emergence.	• Controls annual and perennial grasses and broadleaves. • Expert is a restricted use pesticide (RUP). • Registered for use on forage and grain sorghum. • *Sorghum seed must be treated with a safener (Concep).* • *Do not* apply to coarse-textured soils. • *Do not* apply to medium- or fine-textured soils with less than 1% organic matter. • *Do not* graze or feed forage from treated areas for 60 days after application. • This product contains atrazine; follow the use limitations listed under atrazine.

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant.

Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate / A	Application timings	Remarks and limitations
glyphosate (many trade names) (See Table 8.)	Various formulations	See Table 8 for product rates.	**EPP Burndown:** Apply before planting to control existing vegetation. **PRE Burndown:** Apply after planting but before crop emerges to control existing vegetation.	• Controls grass and broadleaf weed species (Tables 9, 10, 12, 14, and 25). • Application rates vary with weed size, application timing, and formulation. • Table 8 contains a list of glyphosate formulations. • Check labels for individual product restrictions.
G-Max Lite 2.25 lb dimethenamid-P + 2.75 lb atrazine	5L	2.0 to 3.5 pt	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 2 weeks before planting. **PRE:** Apply before crop and weeds emerge. **POST:** Apply to sorghum up to 12 in. tall.	• Controls annual grasses and broadleaf weeds (Tables 12 and 14). • *Sorghum seed must be treated with a safener.* • Registered for use on grain sorghum. • G-Max Lite is a restricted use pesticide (RUP). • G-Max Lite contains less atrazine than Guardsman Max. • *See "Remarks and limitations" for Guardsman Max.*
Gramoxone Inteon paraquat	2S	2.0 to 4.0 pt 1.0 to 2.0 pt	**EPP Burndown:** Apply before planting to control existing vegetation. **PRE Burndown:** Apply after planting but before crop emerges to control existing vegetation. **POST-directed:** Apply when sorghum is at least 12 in. tall.	• Controls existing vegetation (Tables 9 and 10). • Gramoxone Inteon is a restricted use pesticide (RUP). • *Do not* apply broadcast after crop emergence. • *Do not* use around gardens, schools, recreational parks, or playgrounds. • Always add an NIS or a COC to the spray mixture. • Adjust rates according to weed sizes.
Guardsman Max 1.7 lb dimethenamid-P + 3.3 lb atrazine	5L	2.5 to 4.6 pt	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 2 weeks before planting. **PRE:** Apply before crop and weeds emerge. **POST:** Apply to sorghum up to 12 in. tall.	• Controls annual grasses and broadleaf weeds (Tables 12 and 14). • *Sorghum seed must be treated with a safener.* • Registered for use on grain sorghum. • Guardsman Max is a restricted use pesticide (RUP). • *Do not* apply to sweet or forage sorghum. • *Do not* apply to sorghum planted in coarse-textured soils.

(continues)

Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Guardsman Max (cont.)				• This product contains atrazine; follow the use limitations listed under atrazine. • *Do not* graze or feed forage sorghum within 60 days after application. • *Do not* harvest grain or fodder within 80 days after application. • Adjust rates according to soil texture, organic matter, and cation-exchange capacity.
IntRRo, Micro-Tech alachlor	4EC, 4CS	1.5 to 3.0 qt	**PPI:** Apply up to 7 days before planting. **PRE:** Apply to the surface at planting, before crop and weeds emerge, and within 5 days after the last preplant tillage operation.	• Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12). • *Sorghum seed must be treated with a safener (Screen).* • IntRRo and Micro-Tech are restricted use pesticides (RUPs). • Registered for use on grain sorghum (milo). • *Read* and *observe* all environmental precautions. • *Do not* make more than two applications per year or exceed a total of 4 qt/A of IntRRo or MicroTech per year. • *Do not* graze or harvest forage for 70 days following application of this product. • Adjust rates according to soil texture and organic matter.
Laddok S-12 2.5 lb bentazon + 2.5 lb atrazine	5L	1.33 to 2.33 pt	**POST:** Apply to sorghum up to 12 in. tall.	• Controls broadleaf weeds and sedges (Table 14). • Registered for use on grain and forage sorghum. • Laddok is a restricted use pesticide (RUP). • *Do not* make more than one application of Laddok per season. • *Do not* apply to sorghum grown for seed. • *Do not* apply to sorghum that is heading out or blooming. • This product contains atrazine; follow the use limitations listed under atrazine. • An adjuvant is required for consistent weed control.

Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Marksman 1.1 lb dicamba + 2.1 lb atrazine	3.2L	1.5 to 2.0 pt	**PRE:** May be applied at least 15 days before planting. **EPOST:** Apply to sorghum from the 2-leaf to the 5-leaf stage (about 2 to 8 in. tall).	• Controls broadleaf weeds (Table 14). • Marksman is a restricted use pesticide (RUP). • Registered for use on sorghum. • *Do not* apply to sorghum grown for seed. • *Do not* graze or feed forage for 21 days following application. • *Do not* harvest for 45 days following POST application. • *Do not* exceed 3.5 pt/A of Marksman per season. • *Do not* add crop oil after sorghum emergence; *do not* add a surfactant unless possible crop injury is acceptable. • This product contains atrazine; follow the use limitations listed under atrazine. • This product contains dicamba; take precautions to avoid drift onto desirable legumes and broadleaf crops. • Adjust rates according to soil texture and organic matter.
Outlook dimethenamid-P	6EC	8 to 21 fl oz	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 2 weeks before planting. **PRE:** Apply before crop and weeds emerge. **POST:** Apply to sorghum up to 12 in. tall.	• Controls annual grasses and certain small-seeded broadleaf weeds (Table 12). • *Sorghum seed must be treated with a safener.* • Registered for use on grain sorghum. • *Do not* apply to sweet or forage sorghum. • *Do not* graze or feed forage sorghum within 60 days after application. • *Do not* harvest grain or fodder within 80 days after application. • Adjust rates according to soil texture, organic matter, and cation-exchange capacity. • *Will not control emerged weeds.*

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant.

Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Paramount quinclorac	75DF	5.3 to 8.0 oz	**PRE:** Apply prior to sorghum emergence. **POST:** Apply to sorghum up to 12 in. tall.	• Controls certain annual grass and broadleaf species. • Registered for use on grain sorghum. • POST applications require the addition of an MSO or a COC; a nitrogen fertilizer also may be included. • *Do not* apply more than 16 oz/A/year. • *Do not* plant crops other than wheat or sorghum for at least 10 months after application. • *Do not* allow livestock to graze in treated areas. • *Do not* feed treated forage, hay, silage, straw, or seed to livestock.
Permit halosulfuron	75WG	0.67 to 1.0 oz	**POST:** Can be applied to sorghum from the 2-leaf through the layby stage (before grainhead emergence).	• Controls sedges and certain annual broadleaf weeds (Tables 12 and 14). • Registered for use on grain sorghum (milo). • *Do not* exceed 1.0 oz/A of Permit per season. • *Do not* harvest for forage or silage and *do not* graze within 30 days of application. • An NIS or a COC must be used. • Permit will not control ALS-resistant weed species.
Sequence 2.25 lb a.e. glyphosate + 3.0 lb *S*-metolachlor	5.25EW	2.5 to 4 pt	**EPP:** Apply up to 30 days before planting. **PRE:** Apply before crop emergence.	• Controls annual and perennial grasses and broadleaves. • Registered for use on grain and forage sorghum. • *Sorghum seed must be commercially treated with Concep safener.* • *Do not* exceed 3.5 pt/A on coarse-textured soils or 3.75 pt/A on medium-textured soils. • *Do not* apply after sorghum begins to emerge.

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant.

Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Shotgun 2.25 lb atrazine + 1.0 lb a.e. 2,4-D	3.25L	2 pt	**EPOST:** Apply to sorghum from spike to the 4-leaf stage, but before sorghum is 8 in. tall. **POST-directed:** Apply to sorghum at the 5-leaf stage, or to sorghum that is 8 to 12 in. tall.	• Controls broadleaf weeds (Table 14). • Shotgun is a restricted use pesticide (RUP). • Registered for use on sorghum. • This product contains atrazine; follow the use limitations listed under atrazine. • This product contains 2,4-D; take precautions to avoid drift onto desirable legumes and broadleaf crops. • Sorghum is a sensitive crop and may be susceptible to injury from this product.
Starane fluroxypyr	1.5 EC	0.67 pt	**PRE:** Apply prior to sorghum emergence. **POST:** Apply from the 3-leaf stage through the 7-leaf stage. **POST-directed:** Apply from the 8-leaf stage to boot.	• Controls certain annual and perennial broadleaf species. • Registered for use on grain sorghum. • *Do not* make more than 2 applications or apply more than 1.33 pt per acre per season. • *Do not* graze or harvest forage from treated areas within 40 days of application. • *Do not* apply less than 70 days before grain or stover harvest.
Yukon 12.5% halosulfuron + 55% dicamba	67.5WSG	4 to 6 oz	**POST:** Apply to sorghum from the 2-leaf stage up to 8 in. tall. **POST-directed:** Apply to sorghum from 8 to 15 in. tall.	• Controls broadleaf weeds and sedges (Tables 12 and 14). • Registered for use on grain sorghum (milo). • Applications during periods of rapid growth may cause temporary leaning of plants or rolling of leaves. • *Do not* exceed 6 oz/A of Yukon per year. • *Do not* graze or feed treated sorghum forage or silage prior to the mature grain stage. • *Do not* apply to sorghum grown for seed. • This product contains dicamba; take precautions to avoid drift onto desirable legumes and broadleaf crops. • The use of an NIS is required, but it can be replaced with a COC; a nitrogen source is recommended.

Table 3. Soybean herbicides (Read and follow label directions before using product.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
2,4-D (many trade names)	3.8 lb a.e. ester (many)	1 to 2 pt	**Preplant Burndown:** Apply before soybean planting.	• Controls annual and perennial broadleaf weeds (Tables 9 and 10). • *Do not* plant soybeans sooner than 7 days after application of up to 1 pt or sooner than 30 days after application of 2 pt. • *Do not* use on sandy soils. • Plant soybeans at least 1.5 to 2 in. deep; seed furrow should be completely closed.
Aim carfentrazone	1.9EW	0.5 to 1 fl oz	**Preplant Burndown:** Apply before soybean planting.	• Controls some annual broadleaf weeds (Table 14). • Can provide some burndown of existing vegetation.
		0.25 fl oz	**POST:** Apply from the V3 stage up to the V10 stage of soybean.	• POST applications require the addition of an NIS. • *Do not* apply more than 0.023 lb a.i./A per season.
		1 to 1.5 fl oz	**Preharvest:** Apply at least 3 days before harvest.	• *Do not* feed treated soybean forage or soybean hay to livestock. • Will not control PPO-resistant waterhemp.
Assure II quizalofop	0.88EC	5 to 12 fl oz	**Preplant Burndown:** Apply 2.5 to 5 fl oz/A. **POST:** Apply before soybean pod set and at least 80 days before harvest.	• Controls many annual and perennial grass weeds (Table 19). • Preplant burndown applications must include a COC. • POST applications require an NIS or a COC. • *Do not* graze or feed treated soybean forage, hay, or straw to livestock. • *Do not* apply within 80 days of harvest or more than 18 fl oz/A per season. • *Do not* plant rotational grass crops within 120 days of application.
Authority First 62.1% sulfentrazone + 8% cloransulam	70DF	3.23 to 8 oz	**PPI:** Incorporate uniformly into the top 1 to 3 in. of soil. **PRE:** Apply before planting or within 3 days after planting.	• Controls certain annual broadleaf weed species (Table 21). • Can provide some burndown of existing vegetation; include an NIS or a COC and an AMS. • *Do not* apply to soils classified as sand with less than 1% organic matter. • *Do not* feed treated soybean forage or soybean hay to livestock.

EPP = early preplant, PPI = preplant incorporated, PRE = preemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, UAN = urea-ammonium nitrate, AMS = ammonium sulfate.

Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Authority MTZ 18% sulfentrazone + 27% metribuzin	45DF	8 to 20 oz	**Fall:** Apply after October 15 and when the sustained soil temperature at 4 in. is 55°F and declining. **EPP:** Apply up to 45 days before planting. **PPI:** Do not incorporate deeper than 2 in. **PRE:** Apply up to 3 days after planting.	• Controls certain annual broadleaf weed species (Table 21). • Can provide some burndown of existing vegetation; include a COC or an NIS. • Authority MTZ is a restricted use pesticide (RUP). • Certain soybean varieties are sensitive to Authority MTZ. • *Do not* apply after soybeans emerge. • *Do not* apply to soils classified as sand with less than 1% organic matter or to soils with a pH greater than 7.5. • *Do not* graze treated fields or harvest for forage or hay.
Autumn iodosulfuron	10WDG	0.3 oz	**Fall:** Apply after fall harvest but before the ground freezes. **EPP:** Apply at least 90 days before planting soybean.	• Controls certain winter annual broadleaf weeds (Table 9). • Applications require the addition of a COC and a nitrogen fertilizer (UAN or AMS). • Autumn will not provide season-long control of annual grass and broadleaf weed species. • *Do not* apply more than 0.3 oz (0.001875 lb a.i.) per acre per year.
Basagran bentazon	4L	1 to 3 pt	**POST:** Apply to actively growing weeds within the size limits listed on the label.	• Controls broadleaf weeds (Table 22). • Applications require a COC/MSO or a COC/MSO and an UAN. • *Do not* apply more than 2 lb a.i. bentazon/A per season. • *Do not* graze or cut treated soybean fields for forage or hay for at least 30 days after application.
Boundary 5.25 lb S-metolachlor + 1.25 lb metribuzin	6.5EC	1.2 to 3 pt	**EPP:** Apply up to 30 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply before soybeans emerge.	• Controls annual grasses and certain broadleaf weeds (Tables 19 and 21). • Can provide some burndown of existing vegetation. • Soil pH of 7.0 or higher increases the chance of soybean injury. • On soils with pH greater than 7.0, use only the 1.5 pt/A rate. • Treated soybean plants may be grazed or fed to livestock 40 days after the last application of Boundary.

Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Canopy 64.3% metribuzin + 10.7% chlorimuron	75DG	2.25 to 7 oz	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 45 days before planting. **PRE:** Apply before soybeans emerge.	• Controls annual broadleaf weeds (Table 21). • Can provide some burndown of existing vegetation. • Burndown applications must include a COC or an NIS. • On soils with a composite pH greater than 7.0, *do not* exceed 2.25 oz/A. • *Do not* apply after soybeans emerge. • *Do not* graze treated fields or harvest for forage or hay.
Canopy EX 22.7% chlorimuron + 6.8% tribenuron	29.5WDG	1.1 to 3.3 oz	**Fall:** Apply after harvest and before ground freeze. **EPP:** Apply 7 to 14 days before planting.	• Controls certain winter and summer annual broadleaf weeds. • The addition of 2,4-D ester will broaden the weed control spectrum. • Applications must include a COC or an NIS; COC is the preferred additive. • A 14-day soybean planting interval must be observed for applications greater than 2.2 oz per acre. • *Do not* graze treated fields or harvest for forage or hay.
Classic chlorimuron	25DG	1 to 3 oz 1 to 3 oz 0.5 to 0.75 oz	**Fall:** Apply after harvest but before ground freezes. **EPP:** Apply before soybeans emerge. **POST:** Apply after the first trifoliolate has expanded and at least 60 days before soybean maturity.	• Controls broadleaf weeds (Table 22). • Can provide some burndown of existing vegetation; include a COC for burndown applications. • Higher application rates are labeled for fall and EPP applications. • POST applications require an NIS or a COC/MSO; ammonium nitrogen fertilizer may also be required. • *Do not* graze treated fields or harvest for forage or hay.
Cobra or Phoenix lactofen	2EC	6 to 12.5 fl oz 8 to 12.5 fl oz	**PRE:** Consult label for application rates. **POST:** Apply no later than 45 days before harvest, or after the R6 growth stage.	• Controls annual broadleaf weeds (Table 22). • POST applications require the addition of spray additives. Consult respective product labels for recommendations. • *Do not* exceed a total of 25 fl oz/A per season. • *Do not* graze or feed treated soybean forage to livestock or use soybean hay or straw for bedding. • Will not control PPO-resistant waterhemp.

Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Command clomazone	3ME	1.33 to 2.67 pt	**EPP:** Apply up to 30 days before planting. **PRE:** Apply before soybeans emerge. **PPI:** Incorporate no deeper than the top 1 to 2 in. of soil.	• Controls annual grasses and certain broadleaf weeds (Tables 19 and 21). • *Do not* apply Command 3ME within 1,200 feet of towns and housing developments, certain commercial fruit/nut or vegetable production areas, commercial greenhouses, or nurseries. • *Do not* allow livestock to graze on treated soybean plants.
Define flufenacet	4SC	8 to 14 fl oz	**EPP:** Apply up to 14 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply before soybeans emerge.	• Controls annual grasses. • *Do not* apply more than 14 fl oz/A/season. • *Do not* graze or feed forage, hay, or straw to livestock.
Dual II Magnum S-metolachlor	7.64EC	1 to 2 pt	**Fall:** Applications can be made north of Illinois Route 136 after October 31. **EPP:** Apply up to 30 to 45 days before planting. **PPI:** Apply and incorporate within 14 days of planting. **PRE:** Apply during or after planting but before crop and weeds emerge. **POST:** Apply from soybean emergence through the third-trifoliolate stage.	• Controls annual grasses and certain broadleaf weeds (Tables 19 and 21). • *Do not* apply more than 2.5 pt of Dual II Magnum to soybeans during any one crop. • *Do not* apply more than 1.33 pt/A POST. • *Do not* graze or feed treated forage or hay from soybean treated POST. • *Will not control emerged weeds.*

EPP = early preplant, PPI = preplant incorporated, PRE = preemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, UAN = urea-ammonium nitrate, AMS = ammonium sulfate.

Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Express SG tribenuron	50SG	0.25 to 0.5 oz	**EPP:** Apply at least 14 days before planting soybean.	• Controls certain emerged winter annual broadleaf weed sprecies. • Applications require the addition of a spray additive such as an NIS or a COC. • Tank-mixing with a broad-spectrum herbicide will expand burndown efficacy; select spray additives based on the additive limitations of the companion product. • *Do not* apply after soybean planting. • *Do not* allow livestock to graze on, or feed forage, hay, or straw from treated soybean fields.
Extreme 0.17 lb a.e. imazethapyr + 1.473 lb a.e. glyphosate	2.17L	3 pt	**Fall:** Apply after harvest and prior to ground freeze. **Burndown:** Apply prior to planting or preemergence. **POST:** Apply only to ***glyphosate-resistant*** soybean and at least 85 days before harvest.	• Controls grasses and broadleaf weeds when applied burndown or POST (Tables 19 and 22). • All applications of Extreme require the addition of a surfactant and AMS. • *Do not* apply Extreme POST to soybean varieties that are not ***glyphosate-resistant***. • Make only one application of Extreme per season. • *Do not* graze or feed treated soybean forage, hay, or straw to livestock.
FirstRate cloransulam	84WDG	0.3 to 0.75 oz	**EPP:** Apply within 2 weeks of planting for optimal results. **PPI:** Do not apply earlier than 4 weeks before planting. **PRE:** Apply within 2 days after planting for optimal results. **POST:** Apply to soybeans any time prior to the 50% flowering stage.	• Controls broadleaf weeds (Tables 21 and 22). • Can provide some burndown of existing vegetation; include a COC and a liquid nitrogen fertilizer for burndown applications. • POST applications require either an NIS, a COC/MSO, an NIS plus UAN, or a COC/MSO plus UAN. • *Do not* make more than one soil application during a single growing season. • *Do not* apply more than 0.6 oz/A as a POST application. • The cumulative application rate may not exceed 1.05 oz/A/season. • *Do not* harvest soybeans for forage or hay for 14 days after application.

EPP = early preplant, PPI = preplant incorporated, PRE = preemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, UAN = urea-ammonium nitrate, AMS = ammonium sulfate.

Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Flexstar fomesafen	1.88L	0.75 to 1.6 pt	**POST:** Apply before soybeans bloom.	• Controls broadleaf weeds (Table 22). • Make only one application of Flexstar in alternate years. • POST applications require an NIS or a COC/MSO; nitrogen fertilizer also can be added. • Maximum application rate north of Interstate 70 is 1.3 pt/A. • Maximum application rate south of Interstate 70 is 1.6 pt/A. • *Do not* graze treated areas or harvest for forage or hay. • Will not control PPO-resistant waterhemp.
Fusilade DX fluazifop	2EC	4 to 24 fl oz	**POST:** Apply before soybeans bloom.	• Controls many annual and perennial grass weeds (Table 19). • Use 6 to 12 fl oz/A for most annual grass species; higher rates may be needed for perennial grass species. • POST applications require an NIS or a COC; nitrogen fertilizer also can be added. • *Do not* apply more than 32 oz/A/season. • *Do not* graze treated areas or harvest for forage or hay. • *Do not* plant rotational grass crops within 60 days of application.
Fusion 2 lb fluazifop + 0.56 lb fenoxaprop	2.56EC	4 to 14 fl oz	**POST:** Apply before soybeans bloom.	• Controls many annual and perennial grass weeds (Table 19). • POST applications require an NIS or a COC; nitrogen fertilizer also can be added. • *Do not* apply more than 24 oz/A/season. • *Do not* graze treated areas or harvest for forage or hay. • *Do not* plant rotational grass crops within 60 days of application.
Gangster 51% flumioxazin 84% cloransulam	Co-Pack	1.5 to 3 oz flumioxazin + 0.3 to 0.6 oz cloransulam	**Fall:** Apply after harvest and no earlier than October 15. **PRE:** Apply before planting or within 3 days after planting but before soybeans emerge.	• Controls broadleaf weeds (Table 21). • *Do not* graze treated fields or feed treated forage or hay to livestock. • *Do not* apply Gangster in fields where products containing flufenacet, alachlor, metolachlor, or dimethenamid will be used.

Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate / A	Application timings	Remarks and limitations
glyphosate (many trade names) (See Table 8.)	Various formulations	See Table 8 for product rates.	**PRE:** Apply before, during, or after planting but prior to emergence of soybean varieties that are not glyphosate-resistant. **POST:** Apply to ***glyphosate-resistant*** soybean up to the R3 growth stage. **Spot treatment:** Apply prior to initial pod set. **Preharvest:** Allow at least 7 to 14 days between application and harvest.	• Controls grasses and broadleaf weeds (Tables 19 and 22). • Additive requirements can vary by formulation. • Make POST applications only to ***glyphosate-resistant*** soybean.
Gramoxone Inteon paraquat	2S	2.0 to 4 pt 4.5 to 8.0 fl oz 8.0 to 16 fl oz	**EPP Burndown:** Apply before planting to control existing vegetation. **PRE Burndown:** Apply after planting but before crop emergence. **POST-directed:** Apply when soybeans are at least 8 in. tall. **Preharvest:** Do not apply within 15 days of harvest.	• Controls emerged grass and broadleaf weeds. • Gramoxone Inteon is a restricted use pesticide (RUP). • Applications require the addition of an NIS or a COC. • *Do not* graze or harvest for forage or hay. • *Do not* use around home gardens, schools, recreational parks, or playgrounds. • *Do not* apply broadcast after crop emergence. • Adjust rates according to weed size. • **Preharvest applications to indeterminate varieties:** Apply when at least 65% of the seed pods have reached a mature brown color or when seed moisture is 30% or less.
Harmony Extra XP 50% thifensulfuron + 25% tribenuron	75DF	0.3 to 0.6 oz	**EPP:** Apply at least 14 days before planting soybean.	• Controls certain emerged winter annual broadleaf weed species. • Tank-mixing with a broad-spectrum herbicide will expand burndown efficacy; select spray additives based on the additive limitations of the companion product.

Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Harmony Extra SG 33.33% thifensulfuron + 16.67% tribenuron	50SG	0.45 to 0.9 oz		• *Do not* apply after soybean planting. • *Do not* allow livestock to graze on, or feed forage, hay, or straw from treated soybean fields.
Harmony GT XP thifensulfuron	75DF	0.3 to 0.6 oz 0.083 oz	**PRE:** Apply up to 45 days before planting until before soybeans emerge. **POST:** Apply after the first trifoliolate has expanded fully.	• Controls broadleaf weeds (Table 22). • POST applications require an NIS or a COC; nitrogen fertilizer is also required. • Apply no later than 60 days before harvest. • *Do not* graze or feed treated soybean forage or hay to livestock.
IntRRo, Micro-Tech alachlor	4EC, 4ME	2 to 3 qt	**EPP:** Apply up to 30 days before planting. **PPI:** Apply up to 7 days before planting. **PRE:** Apply after planting and before soybean and weed emergence.	• Controls annual grasses and certain broadleaf weeds (Tables 19 and 21). • IntRRo and Micro-Tech are restricted use pesticides (RUPs). • *Do not* make more than one application per year or exceed 3 qt/A per year. • *Do not* feed forage, hay, or straw to livestock.
Linex linuron	4L	1 to 2 pt	**EPP:** Apply up to 30 days before planting. **PRE:** Apply before soybeans emerge.	• Controls certain annual broadleaf weeds (Table 21). • Higher rates are needed for soils high in clay and organic matter. • Shallow planted soybeans have an increased chance for injury. • *Do not* apply after soybeans begin to emerge. • *Do not* feed treated soybean forage or hay to livestock.
Outlook dimethenamid-P	6EC	8 to 21 fl oz	**Fall:** Applications can be made north of Illinois Route 136 after October 1. **EPP:** Apply up to 45 days before planting. **PPI:** Apply and incorporate up to 2 weeks before planting. *(continues)*	• Controls annual grasses and certain broadleaf weeds (Tables 19 and 21). • Make fall applications when soil temperatures at the 4-in. depth are sustained at less than 55°F but before ground freeze. • POST applications will not control emerged weeds. • *Do not* apply more than 21 fl oz/A of Outlook per season. *(continues)*

EPP = early preplant, PPI = preplant incorporated, PRE = preemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, UAN = urea-ammonium nitrate, AMS = ammonium sulfate.

Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Outlook (cont.)			**PRE:** Apply after planting and before soybean emergence. **POST:** Apply from first- to third-trifoliolate leaf stage.	• *Do not* graze or feed treated soybean forage, hay, or straw to livestock.
Poast Plus sethoxydim	1SC	0.75 to 3.0 pt	**Preplant Burndown:** Apply prior to planting for control of existing grass weeds. **POST**: Apply to soybeans until 75 days prior to harvest.	• Controls many annual and perennial grass weeds (Table 19). • Applications require the addition of a COC/MSO; nitrogen fertilizer may also be added. • Only treated seed and hay may be used for livestock grazing or feeding. • *Do not* plant rotational grass crops within 30 days of application.
Prefix 4.34 lb S-metolachlor + 0.95 lb fomesafen	5.3EC	2 to 3 pt	**EPP:** Apply up to 15 days before planting soybean. **PPI:** Incorporate within 7 days after application. **PRE:** Apply before soybeans emerge.	• Controls certain annual grass and broadleaf weed species (Tables 19 and 21). • Make only one application of Prefix in alternate years. • Maximum application rate north of Interstate 70 is 2.5 pt/A. • Maximum appliction rate south of Interstate 70 is 3 pt/A. • *Do not* graze treated areas or harvest for forage or hay. • *Do not* apply metolachlor-containing products in tank mixture or as a sequential application.
Prowl or **Pendimax**	3.3EC	1.2 to 3.6 pt	**Fall:** Apply after harvest between October 1 and December 31 and before ground freeze. **EPP:** Apply up to 45 days before planting when tank-mixed or followed sequentially. **PPI:** Apply up to 60 days before planting; incorporate 3.3EC formulation within 7 days of application.	• Controls annual grasses and certain broadleaf weeds (Tables 19 and 21). • *Do not* apply after soybeans emerge. • Livestock can graze or be fed forage from treated soybean fields.
Prowl H_2O pendimethalin	3.8CS	1.5 to 3.0 pt		

EPP = early preplant, PPI = preplant incorporated, PRE = preemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, UAN = urea-ammonium nitrate, AMS = ammonium sulfate.

Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Prowl or **Pendimax** **Prowl H_2O** **(cont.)**			**PRE:** Apply south of Interstate 80 only; apply at planting or up to 2 days after planting.	
Pursuit imazethapyr	70DG 2AS	1.44 oz 4 fl oz	**EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 45 days before planting. **PRE:** Apply before or at planting. **POST:** Apply before soybeans begin to bloom.	• Controls certain annual grasses and broadleaf weeds (Tables 19, 21, and 22). • Make only one application of Pursuit per season. • POST applications require the addition of an NIS plus UAN or a COC/MSO plus UAN. • *Do not* graze or feed treated soybean forage, hay, or straw to livestock.
Pursuit Plus 0.2 lb imazethapyr + 2.7 lb pendimethalin	2.9EC	2.5 pt	**Fall:** Apply after October 31 and before ground freeze. **EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 45 days before planting. **PRE:** Apply south of Interstate 80 only; apply at planting or up to 2 days after planting.	• Controls certain annual grass and broadleaf weeds (Tables 19 and 21). • Make only one application of Pursuit Plus per season. • *Do not* apply after soybeans emerge. • *Do not* graze or feed treated soybean forage, hay, or straw to livestock.
Python flumetsulam	80WDG	0.8 to 1.33 oz	**EPP:** Apply up to 30 days before planting. **PPI:** Apply up to 30 days before planting. **PRE:** Apply during or after planting but prior to weed emergence.	• Controls annual broadleaf weeds (Table 21). • Can provide some burndown of existing vegetation; include a COC for burndown applications. • *Do not* apply to areas where soil pH is greater than 7.8 or to soils with less than 5% organic matter and pH less than 5.9. • Maximum total flumetsulam active ingredient allowed per growing season is 0.07 lb/A. • *Do not* graze or feed treated soybean forage, hay, or straw to livestock.

Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Raptor imazamox	1AS	4 to 5 fl oz	**POST:** Apply before soybeans bloom.	• Controls certain annual grasses and broadleaf weeds (Tables 19 and 22). • Applications require the addition of an NIS plus UAN or a COC/MSO plus UAN. • Make only one application of Raptor per season. • *Do not* graze or feed treated soybean forage, hay, or straw to livestock.
Resource flumiclorac	0.86EC	4 to 12 fl oz	**POST:** Apply to soybeans up to 60 days before harvest.	• Controls annual broadleaf weeds (Table 22). • POST applications require the addition of a COC/MSO; nitrogen fertilizer also can be added. • Sequential applications may be made at least 14 days apart. • *Do not* apply more than 12 fl oz/A in a single application. • *Do not* apply more than 16 fl oz/A to soybeans during a single growing season. • *Do not* graze or feed treated soybean forage, hay, or straw to livestock.
Rezult B&G B = 5 lb bentazon G = 1 lb sethoxydim	Co-Pack	1.6 pt of B + 1.6 pt of G	**POST:** Apply to soybeans up to 75 days before harvest.	• Controls grasses and broadleaf weeds (Tables 19 and 22). • Applications require the addition of a COC plus a nitrogen fertilizer. • *Do not* apply more than 3.2 pt/A in a single growing season. • *Do not* graze treated soybean fields and *do not* feed treated soybean forage to livestock.
Scepter imazaquin	70DG	1.4 to 2.8 oz	**Fall:** Apply after harvest and before ground freeze. **EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 45 days before planting and incorporate within 7 days of application. **PRE:** Apply before soybeans emerge.	• Controls annual broadleaf weeds (Tables 21 and 22). • Use the 1.4 oz rate for POST applications. • POST applications require the addition of an NIS or a COC with or without a nitrogen fertilizer. • *Do not* apply more than once per year. • *Do not* graze or feed treated soybean forage, hay, or straw to livestock.

EPP = early preplant, PPI = preplant incorporated, PRE = preemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, UAN = urea-ammonium nitrate, AMS = ammonium sulfate.

Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Scepter (cont.)			**POST:** Apply up to 90 days before harvest.	
Select clethodim	2EC	4 to 16 fl oz	**Preplant Burndown:** Apply 3 to 8 fl oz/A. **POST:** Apply to soybeans up to 60 days before harvest.	• Controls many annual and perennial grass weeds (Table 19). • Applications require the addition of a COC; nitrogen fertilizer may also be added. • *Do not* graze treated fields or feed treated forage or hay to livestock. • *Do not* plant rotational grass crops within 30 days of application.
SelectMax clethodim	0.97EC	6 to 32 fl oz	**POST:** Apply to soybean up to 60 days before harvest.	• Controls many annual and perennial grass weeds (Table 19). • Applications require the addition of an NIS or a COC; AMS fertilizer also is required. See tank-mix label for specific adjuvant recommendations. • Additive requirements may change based on tank-mix partner. • *Do not* apply more than 64 fl oz per acre per season. • *Do not* graze treated fields or feed treated forage or hay to livestock.
Sencor metribuzin	75DF	2 oz to 1.16 lb	**EPP:** Apply up to 30 days before planting. **PRE:** Apply before soybean emergence.	• Controls annual broadleaf weeds (Table 21). • Can provide some burndown of existing vegetation; include a COC for burndown applications. • Treated vines may be grazed or fed to livestock 40 days after application. • *Do not* apply to sandy, sandy loam, or loamy sand soils with less than 2% organic matter. • *Do not* incorporate into the soil or apply more than once per season.
Sequence 2.25 lb a.e. glyphosate + 3.0 lb *S*-metolachlor	5.25EW	2.5 to 4 pt 2.5 to 3.5 pt	**EPP:** Apply up to 30 days before planting. **PRE:** Apply before crop emergence. **POST:** Apply only to ***glyphosate-resistant*** varieties through the third-trifoliolate stage.	• Controls annual and perennial grasses and broadleaves. • Application rate is dependent on soil texture and organic matter content. • *Do not* feed treated soybean forage or hay for 30 days after a soil application. • *Do not* graze or feed treated forage or hay from soybean following a POST application.

Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Sonic 62.1% sulfentrazone + 8% cloransulam	70DF	3.23 to 8 oz	**PPI:** Incorporate uniformly into the top 1 to 3 in. of soil. **PRE:** Apply before planting or within 3 days after planting.	• Controls certain annual broadleaf weed species (Table 21). • Can provide some burndown of existing vegetation; include an NIS or a COC and an AMS. • *Do not* apply to soils classified as sand with less than 1% organic matter. • *Do not* feed treated soybean forage or soybean hay to livestock.
Storm 2.67 lb bentazon + 1.33 lb aciflurofen	4SC	1.5 pt	**POST:** Apply to soybeans up to 50 days before harvest.	• Controls annual broadleaf weeds (Table 22). • Applications require the addition of a COC, an NIS, or a nitrogen fertilizer. • *Do not* apply more than 3 pt/A of Storm per season. • Sequential applications may be made at least 15 days apart. • *Do not* use treated plants for livestock feed or forage.
Synchrony XP 21.5% chlorimuron + 6.9% thifensulfuron	28.4DG	1 to 3 oz 0.375 to 1.125 oz	**PRE:** Apply up to 45 days before planting until just before soybean emergence. **POST:** Apply after the first trifoliolate has opened until 60 days prior to soybean maturity.	• Controls broadleaf weeds (Table 22). • POST application rates greater than 0.375 oz/A are for use only on ***STS soybean*** varieties. • Applications require the addition of a COC/MSO and inclusion of an ammonium nitrogen fertilizer. • The 0.375 oz/A rate can be applied POST to non-STS soybean varieties; use an NIS and ammonium nitrogen fertilizer. • *Do not* graze treated areas or harvest for forage or hay.
Treflan HFP trifluralin	4EC	1 to 2.5 pt	**Fall:** Apply and incorporate between October 15 and December 31. **PPI:** Apply and incorporate prior to planting when soil is in good condition to be worked.	• Controls annual grasses and certain broadleaf weeds (Tables 19 and 21). • *Do not* apply when soils are wet or subject to prolonged periods of flooding. • Incorporation should be accomplished within 24 hours of application.

EPP = early preplant, PPI = preplant incorporated, PRE = preemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, UAN = urea-ammonium nitrate, AMS = ammonium sulfate.

Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)

Trade name	Formulation	Rate/A	Application timings	Remarks and limitations
Ultra Blazer acifluorfen	2SC	0.5 to 1.5 pt	**Preplant Burndown:** Apply anytime before planting soybeans. **POST:** Apply up to 50 days prior to soybean harvest.	• Controls annual broadleaf weeds (Table 22). • Applications require the addition of an NIS, COC, AMS, or UAN. • *Do not* apply more than 2 pt/A of Ultra Blazer per growing season. • Allow a minimum of 15 days between sequential applications. • *Do not* use treated plants for feed or forage. • Will not control PPO-resistant waterhemp.
Valor SX flumioxazin	51WDG	2 to 3 oz	**Fall:** Apply no earlier than October 15 but prior to ground freeze. **PRE:** Apply before planting or within 3 days after planting but before soybean emergence.	• Controls annual broadleaf weeds (Table 21). • Can provide some burndown of existing vegetation; include a COC/MSO for burndown applications. • Mechanical incorporation will reduce residual weed control. • *Do not* apply Valor in fields where products containing flufenacet, alachlor, metolachlor, or dimethenamid will be used or soybean injury may occur unless supplemental labeling is followed. • *Do not* apply more than 3 oz/A of Valor per growing season. • *Do not* graze treated fields or feed treated forage or hay to livestock.
Valor XLT 30% flumioxazin 20.3% chlorimuron	40.3WDG	3 to 5 oz	**Fall:** Apply no earlier than October 15 but prior to ground freeze. **PRE:** Apply before planting or within 3 days after planting but before soybeans emerge.	• Controls annual broadleaf species (Table 21). • Can provide some burndown of existing vegetation; tank-mixing with a broad-spectrum herbicide will improve burndown efficacy. • Make only one application per season; do not exceed 5 oz/A/season. • *Do not* apply more than 2.5 oz/A to soils with a pH greater than 6.8. • *Do not* perform any tillage operation after application, or residual weed control will be reduced. • *Do not* graze treated fields or feed treated forage or hay to livestock. • *Do not* apply Valor XLT in fields where products containing flufenacet, alachlor, metolachlor, or dimethenamid will be used or soybean injury may occur unless supplemental labeling is followed.

Table 4. Herbicide and herbicide premix names and restrictions

Trade name(s)	Common name(s)	Restricted use pesticide[a]	Groundwater advisory[b]	Signal word[c]	Crop[d]
AAtrex, Atrazine	atrazine	Yes	Yes	Caution	C
Accent	nicosulfuron	—	—	Caution	C
Aim EW	carfentrazone-ethyl	—	—	Caution	C&S
Assure II	quizalofop	—	—	**Danger**	S
Authority First/Sonic	sulfentrazone + cloransulam	—	Yes	Caution	S
Authority MTZ	sulfentrazone + metribuzin	Yes	Yes	**Danger**	S
Autumn	iodosulfuron	—	—	Caution	C&S
Balance PRO	isoxaflutole	Yes	Yes	Caution	C
Banvel, Clarity	dicamba	—	Yes	Warning, Caution	C
Basagran	bentazon	—	Yes	Caution	C&S
Basis	rimsulfuron + thifensulfuron	—	—	Caution	C
Beacon	primisulfuron	—	—	Caution	C
Bicep II Magnum	*S*-metolachlor + atrazine + safener	Yes	Yes	Caution	C
Bicep Lite II Magnum	*S*-metolachlor + atrazine + safener	Yes	Yes	Caution	C
Boundary	*S*-metolachlor + metribuzin	—	Yes	Caution	S
Buctril	bromoxynil	—	—	Warning	C
Buctril + Atrazine	bromoxynil + atrazine	Yes	Yes	Caution	C
Bullet	alachlor + atrazine	Yes	Yes	Caution	C
Callisto	mesotrione	—	—	Caution	C
Canopy	chlorimuron + metribuzin	—	Yes	Caution	S
Canopy EX	chlorimuron + tribenuron	—	—	Caution	S
Celebrity Plus	nicosulfuron + dicamba + diflufenzopyr	—	Yes	Caution	C
Classic	chlorimuron	—	—	Caution	S
Cobra	lactofen	—	—	**Danger**	S
Command 3ME	clomazone	—	—	Caution	S
Define SC	flufenacet	—	Yes	Caution	C&S
Degree, Harness	acetochlor + safener	Yes	Yes	Caution, Warning	C
Degree Xtra, Harness Xtra	acetochlor + atrazine + safener	Yes	Yes	Caution	C
Distinct/Status	dicamba + diflufenzopyr	—	Yes	Caution	C
Dual II Magnum	*S*-metolachlor + safener	—	Yes	Caution	C&S
Equip	foramsulfuron + iodosulfuron	—	—	Caution	C
Expert	*S*-metolachlor + glyphosate + atrazine	Yes	Yes	Caution	C
		—	—	Caustion	C&S
Express SG	tribenuron	—	—	Caution	C&S
Extreme	imazethapyr + glyphosate	—	Yes	Warning	S
FieldMaster	glyphosate + acetochlor + atrazine + safener	Yes	Yes	Caution	C
FirstRate	cloransulam	—	Yes	Caution	S
Flexstar	fomesafen	—	Yes	Warning	S
FulTime, Keystone, Breakfree ATZ	acetochlor + atrazine + safener	Yes	Yes	Caution, Warning	C
Fusilade DX	fluazifop	—	—	Caution	S
Fusion	fluazifop + fenoxaprop	—	—	Caution	S
Gangster	flumioxazin + cloransulam	—	Yes	Caution	S
Gramoxone Inteon	paraquat	Yes	—	**Danger–Poison**	C&S
Guardsman Max, G-Max Lite	dimethenamid-P + atrazine	Yes	Yes	Caution, Warning	C
Halex GT	*S*-metolachlor + glyphosate + mesotrione	—	Yes	Caution	C
Harmony Extra XP/SG	thifensulfuron + tribenuron	—	—	Caution	C&S
Harmony GT XP	thifensulfuron	—	—	Caution	C&S
Hornet WDG	flumetsulam + clopyralid	—	Yes	Warning	C
Impact	topramezone	—	—	Caution	C
IntRRo, Micro-Tech	alachlor	Yes	Yes	**Danger**, Caution	S

Table 4. Herbicide and herbicide premix names and restrictions (cont.)

Trade name(s)	Common name(s)	Restricted use pesticide[a]	Groundwater advisory[b]	Signal word[c]	Crop[d]
Keystone LA, Breakfree ATZ Lite	acetochlor + atrazine + safener	Yes	Yes	Caution	C
Laddok S-12	bentazon + atrazine	Yes	Yes	**Danger**	C
Lexar	*S*-metolachlor + mesotrione + atrazine	Yes	Yes	Caution	C
Liberty	glufosinate	—	—	Warning	C
Lightning	imazethapyr + imazapyr	—	Yes	Warning	C
Linex	linuron	—	Yes	Caution	S
Lumax	*S*-metolachlor + atrazine + mesotrione	Yes	Yes	Caution	C
Many	2,4-D amine	—	Yes	**Danger**	C
Many	2,4-D ester	—	—	Caution	C
Many	glyphosate (see Table 8)	—	—	Caution	C&S
Marksman	dicamba + atrazine	Yes	Yes	Caution	C
NorthStar	primisulfuron + dicamba	—	Yes	Caution	C
Option	foramsulfuron + safener	—	—	Caution	C
Outlook	dimethenamid-P	—	Yes	Warning	C&S
Permit	halosulfuron	—	—	Caution	C
Phoenix	lactofen	—	Yes	Caution	S
Poast Plus	sethoxydim	—	—	Caution	S
Prefix	*S*-metolachlor + fomesafen	—	Yes	Warning	S
Princep, Simazine	simazine	—	Yes	Caution	C
Prowl, Pendimax	pendimethalin	—	—	Caution	C&S
Pursuit DG	imazethapyr	—	Yes	Warning	C&S
Pursuit Plus	pendimethalin + imazethapyr	—	Yes	Caution	C&S
Python	flumetsulam	—	Yes	Caution	C&S
Radius	flufenacet + isoxaflutole	Yes	Yes	Caution	C
Raptor	imazamox	—	—	Caution	S
Resolve	rimsulfuron	—	—	Caution	C
Resource	flumiclorac	—	—	Warning	C&S
Rezult B + G	bentazon + sethoxydim	—	Yes	**Danger**	S
Scepter	imazaquin	—	—	Caution	S
Select, Select Max	clethodim	—	—	Warning	S
Sencor	metribuzin	—	Yes	Caution	C&S
Sequence	*S*-metolachlor + glyphosate	—	Yes	Caution	S
Shotgun	atrazine + 2,4-D	Yes	Yes	**Danger**	C
Spirit	primisulfuron + prosulfuron	—	Yes	Caution	C
Starane	fluroxypyr	—	—	Warning	C
Steadfast	nicosulfuron + rimsulfuron	—	—	Caution	C
Steadfast ATZ	nicosulfuron + rimsulfuron + atrazine	Yes	Yes	Caution	C
Stinger	clopyralid	—	Yes	Caution	C
Storm	bentazon + acifluorfen	—	Yes	**Danger**	S
SureStart	acetochlor + clopyralid + flumetsulam	—	Yes	Caution	C
Surpass, Breakfree, TopNotch	acetochlor + safener	Yes	Yes	Warning, Caution	C
Synchrony XP	chlorimuron + thifensulfuron	—	—	Caution	S
Treflan HFP	trifluralin	—	—	Caution	S
Ultra Blazer	acifluorfen	—	Yes	**Danger**	S
Valor SX	flumioxazin	—	—	Caution	S
Valor XLT	flumioxazin + chlorimuron	—	—	Caution	S
Yukon	halosulfuron + dicamba	—	Yes	Caution	C

[a]To be applied by licensed applicator.
[b]Special precautions in sandy soils.
[c]Signal word = toxicity signal; indicates need for extra precautions. The signal words "**Danger**" and "Warning" often indicate pesticides that can irritate skin and eyes, necessitating protective clothing, gloves, and goggles or faceshield.
[d]C = corn; S = soybeans.

Table 5a. Corn–sorghum herbicide recropping restrictions, months

Herbicide[a]	Comments	Field corn	Sorghum	Wheat	Oats	Rye	Alfalfa	Clover	Soybeans
Acetochlor and its premixes									
Degree, Harness	acetochlor	AT	NY	4	2Y	2Y	2Y	2Y	NY
Degree Xtra, Harness Xtra 5.6L	w/atrazine	AT	NY	15	2Y	2Y	2Y	2Y	NY
FulTime, Keystone, Keystone LA, Breakfree ATZ, Breakfree ATZ Lite	w/atrazine	AT	NY	15	15	2Y	15	2Y	NY[b]
Surpass, TopNotch, Breakfree	acetochlor	AT	NY	4	2Y	2Y	2Y	2Y	NY
Atrazine and its premixes; simazine									
AAtrex, Atrazine	pH < 7.2	AT	AT	NY	2Y	NY	2Y	2Y	NY[b]
Bicep II Magnum	w/*S*-metolachlor	AT	AT[c]	NY	2Y	NY	2Y	2Y	NY[b]
Bicep Lite II Magnum	w/*S*-metolachlor	AT	AT[c]	NY	2Y	NY	2Y	2Y	NY[b]
Buctril + Atrazine	w/bromoxynil	AT	AT	NY	2Y	NY	2Y	2Y	NY
Bullet	w/alachlor	AT	AT[c]	NY	2Y	NY	2Y	2Y	NY[b]
Expert	w/*S*-metolachlor + glyphosate	AT	AT[c]	NY	2Y	NY	2Y	2Y	NY[b]
Guardsman Max, G-Max Lite	w/dimethenamid-P	AT	AT[c]	NY	2Y	NY	2Y	2Y	NY
Laddok S-12	w/bentazon	AT	AT	15	15	15	18	18	NY
Lexar	w/*S*-metolachlor + mesotrione	AT	NY	NY	2Y	NY	2Y	2Y	NY
Lumax	w/*S*-metolachlor + mesotrione	AT	NY	4.5	NY	4.5	18	18	NY
Marksman	w/dicamba	AT	AT	10	2Y	10	2Y	2Y	NY[b]
Princep, simazine	simazine	AT	NY	NY	2Y	NY	2Y	2Y	NY
Steadfast ATZ	w/nicosulfuron + rimsulfuron	AT	10	10[b]	18[b]	10[b]	18[b]	18[b]	10[b]
Flumetsulam, clopyralid, and premixes									
Hornet WDG	w/clopyralid	AT	12	4	4	4	10.5[e]	26[Fba]	10.5[e]
Python	flumetsulam	AT	12	4	4	4	4	26[Fba]	AT
Stinger	clopyralid	AT	10.5	AT	AT	AT	10.5	18	10.5[e]
SureStart	w/acetochlor	AT	12	4	NY	NY	NY	NY	NY
Isoxaflutole, flufenacet, and premix									
Balance PRO	isoxaflutole	AT	6	4	18	18	10[e]	18	6
Define SC	flufenacet	AT	12	12	12	12	12	12	AT
Radius	flufenacet + isoxaflutole	AT	12	12	18	12	12[e]	18	6
Mesotrione									
Callisto	mesotrione	AT	10	4	4	4	10	18	10
Halex GT	w/*S*-metolachlor + glyphosate	AT	AT	4	18	4	10	18	10
Imazethapyr and its premixes									
Lightning	w/imazapyr	8.5[f]	18	4	18	4	9.5	40[Fba]	9.0
Pursuit	imazethapyr	8.5[f]	18	3	18	4	4	40[Fba]	AT
Pursuit Plus	w/pendimethalin	8.5[f]	18	4	18	9.5	9.5	40[Fba]	AT

Table 5a. Corn–sorghum herbicide recropping restrictions, months (cont.)

Herbicide[a]	Comments	Field corn	Sorghum	Wheat	Oats	Rye	Alfalfa	Clover	Soybeans
Sulfonylureas and their premixes									
Accent	nicosulfuron	AT	10[d]	4	8	4	10	10	0.5
Autumn	iodosulfuron	1	9	4	9	4	18	18	3
Basis	thifensulfuron + rimsulfuron	AT	10	4	8	18	10	18	0.5
Beacon	primisulfuron	0.5	8	3	8	3	8	18	8
Celebrity Plus	dicamba + nicosulfuron + diflufenzopyr	0.25	10[d]	4	8	4	12	12	4
Equip	foramsulfuron + iodosulfuron	0.5	9	2	9	2	18	18	9
NorthStar	primisulfuron + dicamba	0.5	8	3	8	3	8	18	8
Option	foramsulfuron	0.25	2	2	2	2	2	2	0.5
Permit	halosulfuron	1	2	2	2	2	9	9	9
Resolve	rimsulfuron	AT	10[e]	4	9	18	10[e]	10[e]	10
Spirit	primisulfuron + prosulfuron	1	10	3	3	3	18[g]	18[g]	10–18[h]
Steadfast	nicosulfuron + rimsulfuron	AT	10[d]	4	8	4	10	10	0.5
Steadfast ATZ	nicosulfuron + rimsulfuron + atrazine	AT	10	10	18	10	18	18	10
Yukon	halosulfuron + dicamba	1	2	2	2	2	9	9	9
Other active ingredients									
Define	flufenacet	AT	12	12	12	12	12	12	AT
Impact	topramezone	AT	9	3	3	3	9	18	9

[Fba] = field bioassay needed (see label); NY = next year; 2Y = second year; AT = anytime; d = days.
[a]Other corn herbicides have no significant recropping restrictions, but Banvel, Clarity, and 2,4-D have replanting limits for soybeans.
[b]2Y (second year) if applied after June 10 with high atrazine or Liberty ATZ and after July 1 with Basis Gold or Steadfast ATZ.
[c]Concep or Screen seed protectant needed.
[d]18 months if pH ≥ 7.5.
[e]18 months if < 15 inches of rainfall received and if soil has < 2% organic matter.
[f]Clearfield (CL) corn hybrids may be replanted anytime.
[g]Spirit: pH < 7.8, applied before July 1, rainfall > 12 inches within 5 months and > 1 inch within 4 weeks of application.
[h]I-70 to I-80: Spirit 10 months. North of I-80: Spirit 18 months.

Table 5b. Soybean herbicide recropping restrictions, months

Herbicide	Comments	Field corn	Sorghum	Wheat	Oats	Rye	Alfalfa	Clover	Soybeans
Chlorimuron and its premixes									
Canopy	w/metribuzin	10	12	4	30	4	10	12	AT
Canopy EX[a]	w/tribenuron	10	12	4	30	4	10	12	AT
Classic	high chlorimuron	9[b]	9[b]	3	3	3	12[b]	12[b]	AT
Synchrony XP	w/thifensulfuron	9[b]	9[b]	3	3	3	12[b]	12[b]	AT
Valor XLT	w/flumioxazin	10	10	4	30	4	12	18	AT
Cloransulam and flumetsulam; cloransulam premixes									
FirstRate	cloransulam	9	9	3	9	30[Fba]	9	30[Fba]	AT
Gangster	w/flumioxazin	9	9	3	9	30[Fba]	30[Fba]	30[Fba]	AT
Python	flumetsulam	AT	12	4	4	4	4	26[Fba]	AT
Sonic/Authority First	w/sulfentrazone	10	12	4	12	12	12	30[Fba]	AT
Imazaquin (Region 3 = north of Peoria)									
Scepter—Region 2[c]	imazaquin	9.5[d,e]	11[e]	3[e]	11[e]	18	18	18	AT
Scepter—Region 3[c]	0.5 rate, post	NY[d]	11	Fall[e]	NY[e]	18	18	18	AT
Scepter—Region 3[c]	imazaquin	18	11	18	18	18	18	18	AT
Imazethapyr and its premixes									
Extreme	w/glyphosate	8.5[f]	18	4	18	4	4	4	AT
Pursuit	imazethapyr	8.5[f]	18	3	18	4	4	40	AT
Pursuit Plus	w/pendimethalin	8.5[f]	18	4	18	9.5	9.5	40	AT
Metribuzin and its premix									
Authority MTZ	w/sulfentrazone	10	12	4	18	18	12	18	4
Boundary	w/*S*-metolachlor	8	12	4.5	12	12	4.5	12	AT
Sencor	metribuzin	4	12	4	12	12	4	12	4
Other active ingredients									
Autumn	iodosulfuron	1	9	4	9	4	18	18	3
Command 3ME	clomazone	9	9	12	12[g]	12[g]	12[g]	12[g]	AT
Define	flufenacet	AT	12	12	12	12	12	12	AT
Flexstar	fomesafen	10	18	4	4	4	18	18	AT
Linex	linuron	AT	AT	4	4	4	4	4	AT
Pendimax/Prowl	pendimethalin	NY	NY	4	NY	NY	NY	NY	AT
Prefix	fomesafen + *S*-metolachlor	10	18	4.5	4.5	4.5	18	18	AT
Raptor	imazamox	8.5	9	3	9	4	3	18	AT
Sequence	*S*-metolachlor + glyphosate	AT	AT	4.5	4.5	4.5	4	9	AT
Treflan	trifluralin	NY	12	NY	12	12	NY	NY	AT
Valor SX	flumioxazin	1[h]	1[h]	2[h]	12	4	12	12	AT

[Fba] = field bioassay needed (see label); NY = next year; 2Y = second year; AT = anytime.
[a]Midwest states' rate, soil pH < 7.
[b]Extend 2 months if applied after August 1.
[c]See label for exact area and Region 3 (northern Illinois) full-use rate.
[d]10- to 15-inch annual rainfall is required, or use CL-corn hybrids.
[e]15 months if Scepter/Scepter sequence, but 9.5 months or NY for CL-corn hybrids.
[f]Clearfield (CL) corn hybrids may be replanted anytime.
[g]Cover crops may be planted anytime, but stand reductions may occur. Do not graze or harvest for forage for at least 9 months.
[h]30 days following applications of 2 ounces per acre or less and at least one inch of precipitation.

Table 6. Corn herbicide premixes, or co-packs, and equivalents

Herbicide	Components (a.i./gal or lb)	If you apply (per acre) . . .	You have applied (a.i.)	An equivalent rate of
Basis 75WDG	0.50 lb rimsulfuron 0.25 lb thifensulfuron	0.33 oz	0.01 lb rimsulfuron 0.005 lb thifensulfuron	0.66 oz Resolve 25WDG 0.11 oz Harmony GT XP 75DF
Bicep II Magnum 5.5L	2.40 lb *S*-metolachlor 3.1 lb atrazine	2.1 qt	1.26 lb *S*-metolachlor 1.63 lb atrazine	0.66 qt Dual II Magnum 7.64EC 1.62 qt AAtrex 4L
Bicep Lite II, Magnum 6L	3.33 lb *S*-metolachlor 2.67 lb atrazine	1.5 qt	1.25 lb *S*-metolachlor 1.00 lb atrazine	0.65 qt Dual II Magnum 7.64EC 1.00 qt AAtrex 4L
Buctril + Atrazine 3L	1.0 lb bromoxynil 2.0 lb atrazine	2 pt	0.25 lb bromoxynil 0.50 lb atrazine	1 pt Buctril 2EC 1 pt AAtrex 4L
Bullet 4CS	2.5 lb alachlor 1.5 lb atrazine	4 qt	2.5 lb alachlor 1.5 lb atrazine	2.5 qt Micro-Tech 4CS 1.5 qt AAtrex 4L
Camix 3.67	3.34 lb *S*-metolachlor 0.33 lb mesotrione	2 qt	1.67 lb *S*-metolachlor 0.165 lb mesotrione	1.75 pt Dual II Magnum 7.64EC 5.28 oz Callisto 4SC
Celebrity Plus 70WDG	0.42 lb dicamba 0.17 lb diflufenzopyr 0.106 lb nicosulfuron	4.7 oz	0.125 lb dicamba 0.049 lb diflufenzopyr 0.031 lb nicosulfuron	4.0 oz Distinct 70WDG 0.66 oz Accent 75DF 2.13 qt Degree 3.8CS 1 qt AAtrex 4L
Degree Xtra 4.04CS	2.7 lb acetochlor 1.34 lb atrazine	3 qt	2.025 lb acetochlor 1.0 lb atrazine	0.075 lb a.i. diflufenzopyr 6 fl oz Clarity 4S
Distinct 70WDG	0.2 lb diflufenzopyr 0.5 lb dicamba	6 oz	0.075 lb diflufenzopyr 0.188 lb dicamba	1.28 oz Option 35WDG 0.0019 lb a.i. iodosulfuron
Equip 32WDG	0.30 lb foramsulfuron 0.02 lb iodosulfuron	1.5 oz	0.028 lb foramsulfuron 0.0019 lb iodosulfuron	1.37 pt Dual II Magnum 7.64EC 1.6 qt AAtrex 4L 1.48 pt glyphosate 3L
Expert 4.88SC	1.74 lb *S*-metolachlor 2.14 lb atrazine 0.74 lb a.e. glyphosate	3 qt	1.31 lb *S*-metolachlor 1.61 lb atrazine 0.555 lb a.e. glyphosate	2.3 pt Harness 7EC 3.0 pt AAtrex 4L 1.5 pt Roundup 3L
FieldMaster 4.06S	2.0 lb acetochlor 1.5 lb atrazine 0.56 lb a.e. glyphosate	4 qt	2.0 lb acetochlor 1.5 lb atrazine 0.56 lb a.e. glyphosate	3.00 qt TopNotch 3.2CS 1.6 qt AAtrex 4L
FulTime 4CS	2.4 lb acetochlor 1.6 lb atrazine	4 qt	2.4 lb acetochlor 1.6 lb atrazine	18 fl oz Outlook 6EC 2 pt AAtrex 4L
G-Max Lite 5L	2.25 lb dimethenamid-P 2.75 lb atrazine	3.0 pt	0.84 lb dimethenamid-P 1.0 lb atrazine	18 fl oz Outlook 6EC 3.3 pt AAtrex 4L
Guardsman Max 5L	1.7 lb dimethenamid-P 3.3 lb atrazine	4.0 pt	0.85 lb dimethenamid-P 1.65 lb atrazine	
Halex GT	2.09 lb *S*-metolachlor 2.09 lb a.e. glyphosate 0.209 lb mesotrione	3.6 pt	0.94 lb *S*-metolachlor 0.94 lb glyphosate 0.094 lb mesotrione	0.98 pt Dual II Magnum 7.64EC 2.5 pt Glyphosate 3L 3 fl oz Callisto 4SC
Harness Xtra 5.6L	3.1 lb acetochlor 2.5 lb atrazine	5.0 pt	1.94 lb acetochlor 1.56 lb atrazine	2.21 pt Harness 7E 3.12 pt AAtrex 4L
Hornet WDG 68.5WDG	0.185 lb flumetsulam 0.5 lb a.e. clopyralid	4 oz	0.046 lb flumetsulam 0.125 lb clopyralid	0.93 oz Python 80WDG 5.3 fl oz Stinger 3S

Table 6. Corn herbicide premixes, or co-packs, and equivalents (cont.)

Herbicide	Components (a.i./gal or lb)	If you apply (per acre) . . .	You have applied (a.i.)	An equivalent rate of
Keystone 5.25L, Breakfree ATZ	3.0 lb acetochlor 2.25 lb atrazine	2.7 qt	2.03 lb acetochlor 1.52 lb atrazine	2.5 pt Surpass 6.4EC 3.0 pt AAtrex 4L
Keystone LA 5.5L, Breakfree ATZ Lite	4 lb acetochlor 1.5 lb atrazine	2 qt	2 lb acetochlor 0.75 lb atrazine	2.5 pt Surpass 6.4EC 1.5 pt AAtrex 4L
Laddok S-12 5L	2.5 lb bentazon 2.5 lb atrazine	1.67 pt	0.52 lb bentazon 0.52 lb atrazine	1.0 pt Basagran 4S 1.0 pt AAtrex 4L
Lexar 3.7L	1.74 lb *S*-metolachlor 1.74 lb atrazine 0.224 lb mesotrione	3.5 qt	1.52 lb *S*-metolachlor 1.52 lb atrazine 0.196 lb mesotrione	1.6 pt Dual II Magnum 7.64EC 3 pt AAtrex 4L 6.27 fl oz Callisto 4SC
Lightning 70DG[a]	0.525 lb imazethapyr 0.175 lb imazapyr	1.28 oz	0.042 lb imazethapyr 0.014 lb imazapyr	0.96 oz Pursuit 70DG 0.896 fl oz Arsenal 2AS
Lumax 3.95L	2.68 lb *S*-metolachlor 0.268 lb mesotrione 1.0 lb atrazine	3.0 qt	2.01 lb *S*-metolachlor 0.20 lb mesotrione 0.75 lb atrazine	1.0 qt Dual II Magnum 7.64EC 6.4 fl oz Callisto 4SC 0.75 qt AAtrex 4L
Marksman 3.2L	1.1 lb dicamba 2.1 lb atrazine	3.5 pt	0.48 lb dicamba 0.92 lb atrazine	0.96 pt Banvel 4S 1.84 pt AAtrex 4L
NorthStar 47.4WDG	0.075 lb primisulfuron 0.399 lb dicamba	5 oz	0.023 lb primisulfuron 0.125 lb dicamba	0.50 oz Beacon 75WDG 4.00 fl oz Banvel 4S
Radius 4SC	3.57 lb flufenacet 0.43 lb isoxaflutole	20 fl oz	0.558 lb flufenacet 0.067 lb isoxaflutole	17.9 fl oz Define 4SC 2.15 fl oz Balance PRO 4SC
Shotgun 3.25F	2.25 lb atrazine 1 lb a.e. 2,4-D	3 pt	0.84 lb atrazine 0.375 lb a.e. 2,4-D	1.68 pt AAtrex 4L 0.6 pt Salvo 5E
Spirit 57WDG	0.428 lb primisulfuron 0.142 lb prosulfuron	1 oz	0.027 lb primisulfuron 0.009 lb prosulfuron	0.57 oz Beacon 75WDG 0.25 oz Peak 57WDG
Status 56WDG	0.16 lb diflufenzopyr 0.4 lb dicamba	5 oz	0.05 lb diflufenzopyr 0.125 lb dicamba	0.05 lb a.i. diflufenzopyr 4 fl oz Clarity 4S
Steadfast 75WDG	0.5 lb nicosulfuron 0.25 lb rimsulfuron	0.75 oz	0.023 lb nicosulfuron 0.012 lb rimsulfuron	0.5 oz Accent 75DF 0.75 oz Resolve 25WDG
Steadfast ATZ 89.3WDG	0.027 lb nicosulfuron 0.013 lb rimsulfuron 0.853 lb atrazine	14 oz	0.024 lb nicosulfuron 0.011 lb rimsulfuron 0.746 lb atrazine	0.5 oz Accent 75DF 0.73 oz Resolve 25WDG 0.83 lb AAtrex 90DF
SureStart 4.16SE	3.75 lb acetochlor 0.12 lb flumetsulam 0.29 lb a.e. clopyralid	2 pt	0.94 lb acetochlor 0.03 lb flumetsulam 0.07 lb a.e. clopyralid	1.17 pt Surpass 6.4EC 0.6 oz Python 80WDG 3.1 fl oz Stinger 3S
Yukon 67.5WSG	0.125 lb halosulfuron 0.50 lb dicamba	4 oz	0.03 lb halosulfuron 0.125 lb dicamba	0.67 oz Permit 75WSG 4 fl oz Banvel 4S

[a] Use only on Clearfield (CL) corn hybrids.

Table 7. Soybean herbicide premixes, or co-packs, and equivalents

Herbicide	Components (a.i./gal or lb)	If you apply (per acre) . . .	You have applied (a.i.)	An equivalent rate of
Authority First/ Sonic 70DF	0.621 lb sulfentrazone 0.08 lb cloransulam	6.4 oz	0.248 lb sulfentrazone 0.32 lb cloransulam	5.3 oz Authority 75DF 0.6 oz FirstRate 84 WDG
Authority MTZ 45DF	0.18 lb sulfentrazone 0.27 lb metribuzin	20 oz	0.23 lb sulfentrazone 0.338 lb metribuzin	4.8 oz Authority 75DF 7.2 oz Sencor 75DF
Boundary 6.5EC	5.25 lb *S*-metolachlor 1.25 lb metribuzin	2.5 pt	1.64 lb *S*-metolachlor 0.391 lb metribuzin	1.72 pt Dual Magnum 7.62EC 12.5 fl oz Sencor 4L
Canopy 75DG	0.107 lb chlorimuron 0.643 lb metribuzin	4 oz	0.027 lb chlorimuron 0.161 lb metribuzin	1.71 oz Classic 25DG 3.43 oz Sencor 75DF
Canopy EX 29.5WDG	0.227 lb chlorimuron 0.068 lb tribenuron	1.1 oz	0.016 lb chlorimuron 0.005 lb tribenuron	1.00 oz Classic 25DG 0.1 oz Express XP 75DF
Extreme 2.17L[a]	0.17 lb imazethapyr 1.473 lb a.e. glyphosate	3 pt	0.063 lb imazethapyr 0.552 lb a.e. glyphosate	4 fl oz Pursuit 2AS 1.47 pt Roundup 3L
Fusion 2.56EC	2 lb fluazifop 0.56 lb fenoxaprop	8 fl oz	0.125 lb fluazifop 0.035 lb fenoxaprop	8 fl oz Fusilade DX 2EC 4.48 fl oz Puma 1EC
Gangster V&FR (co-pack)	0.51 lb flumioxazin 0.84 lb cloransulam	3 oz 0.6 oz	0.096 lb flumioxazin 0.032 lb cloransulam	3 oz Valor SX 51WDG 0.6 oz FirstRate 84WDG
Prefix 5.3EC	4.34 lb *S*-metolachlor 0.95 lb fomesafen	2 pt	1.09 lb *S*-metolachlor 0.238 lb fomesafen	1.14 pt Dual Magnum 7.62 EC 0.95 pt Reflex 2EC
Pursuit Plus 2.9EC	0.2 lb imazethapyr 2.7 lb pendimethalin	2.5 pt	0.063 lb imazethapyr 0.84 lb pendimethalin	4 fl oz Pursuit 2AS 2 pt Prowl 3.3EC
Rezult B&G (co-pack)	B = 5.0 lb bentazon G = 1.0 lb sethoxydim	1.6 pt 1.6 pt	1.00 lb bentazon 0.20 lb sethoxydim	2.0 pt Basagran 4S 1.6 pt Poast Plus 1E
Sequence 5.25L	3.0 lb *S*-metolachlor 2.25 lb a.e. glyphosate	3 pt	1.13 lb *S*-metolachlor 0.84 lb a.e. glyphosate	1.18 pt Dual Magnum 7.62EC 26 fl oz Touchdown Total 4.17L
Storm 4S	2.67 lb bentazon 1.33 lb acifluorfen	1.5 pt	0.50 lb bentazon 0.25 lb acifluorfen	1 pt Basagran 4S 1 pt Blazer 2S
Synchrony XP 28.4DG[b]	0.215 lb chlorimuron 0.069 lb thifensulfuron	0.75 oz	0.01 lb chlorimuron 0.003 lb thifensulfuron	0.64 oz Classic 25DF 0.068 oz Harmony GT XP 75DF
Valor XLT 40.3WDG	0.3 lb flumioxazin 0.103 lb chlorimuron	3 oz	0.056 lb flumioxazin 0.019 lb chlorimuron	1.76 oz Valor 51WDG 1.24 oz Classic 25DF

[a]Use postemergence only on glyphosate-resistant varieties.
[b]Use only on STS (sulfonylurea-tolerant) varieties at this rate.

Table 8. Glyphosate formulations and product equivalents

Trade name	Company	Active ingredient/ acid equivalent per gallon or pound	Product rate equivalent to 0.375 lb a.e.	0.56 lb a.e.	0.75 lb a.e.	1.13 lb a.e.	Crop[a]
			..... *fl oz*				
Cornerstone	Agriliance	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Cornerstone Plus	Agriliance	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Rascal	Agriliance	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Rascal Plus	Agriliance	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Gly Star Original	Albaugh, Inc./ Agri Star	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Gly Star Plus	Albaugh, Inc./ Agri Star	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
ClearOut 41 Plus	Chemical Product Technologies, LLC	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Glyfos	Cheminova	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Glyfos X-TRA	Cheminova	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Duramax	DowAgroSciences	5.4 lb a.i./4 lb a.e.	12	18	24	36	C&S
Durango DMA	DowAgroSciences	5.4 lb a.i./4 lb a.e.	12	18	24	36	C&S
FS Glyphosate Plus	Growmark	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Rattler Plus	Helena	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Glyphosate 41%	Helm Agro USA	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Mirage	Loveland	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Mirage Plus	Loveland	4 lb a.i./ 3 lb a.e.	16	24	32	48	C&S
Gly-Flo	Micro Flo	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Honcho	Monsanto	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Honcho Plus	Monsanto	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Roundup PowerMAX	Monsanto	5.5 lb a.i./4.5 lb a.e.	11	16	22	32	C&S
Roundup Weathermax	Monsanto	5.5 lb a.i./4.5 lb a.e.	11	16	22	32	C&S
Credit	Nufarm	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Credit Extra	Nufarm	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Touchdown	Syngenta	3.7 lb a.i./3 lb a.e.	16	24	32	48	C&S
Touchdown HiTech	Syngenta	6.16 lb a.i./5 lb a.e.	10	14	19	29	C&S
Touchdown Total	Syngenta	5.14 lb a.i./4.17 lb a.e.	11.5	17	23	35	C&S
Buccaneer	Tenkoz	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Buccaneer Plus	Tenkoz	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Gly-4	Universal Crop Protection Alliance	4 lb a.i./3 lb a.e.	16	24	32	48	C&S
Gly-4 Plus	Universal Crop Protection Alliance	4 lb a.i./3 lb a.e.	16	24	32	48	C&S

[a]Labeled for use in glyphosate-resistant corn hybrids (C) and/or soybean varieties (S).

Table 9. Control ratings for herbicides to control existing vegetation in no-till corn and soybean

		Winter annual grasses					Winter annual broadleaves					Summer annuals						Perennials			
Herbicide	Crop[a]	Barley, little	Bluegrass, annual	Brome, downy	Ryegrass, annual	Rye or wheat cover	Chickweed, common	Henbit/purple deadnettle	Horseweed (marestail)	Mustards	Prickly lettuce	Foxtail, giant	Fleabane, daisy or annual	Lambsquarters, common	Ragweed, common	Ragweed, giant	Smartweed, Pennsylvania	Alfalfa	Dandelion, common	Clover, red	Vetch, hairy
2,4-D ester[b]	C&S	0	0	0	0	0	5	5	8	9	8	0	6	9	9	8	7	6	8	7	9
2,4-D + Clarity or Banvel[b,c]	**C&S**	**0**	**0**	**0**	**0**	**0**	**8**	**6**	**8**	**9**	**9**	**0**	**8**	**9**	**9**	**9**	**8**	**8**	**9**	**8**	**9**
2,4-D + glyphosate[b]	C&S	9	9	9	9	9	9	9	9	9	9	9	6	9	9	9	8	6	8	8	8
atrazine	**C**	**9**	**9**	**7**	**6**	**6**	**9**	**9**	**8**	**9**	**9**	**7**	**7**	**9**	**9**	**9**	**9**	**4**	**6**	**4**	**7**
Autumn + 2,4-D[b]	C&S	0	0	0	0	0	9	8	8	9	8	0	—	—	—	—	—	6	8	7	9
Balance PRO	**C**	**—**	**—**	**6**	**—**	**5**	**8**	**6**	**7**	**8**	**8**	**8**	**—**	**8**	**8**	**6**	**8**	**0**	**0**	**6**	**0**
Balance PRO + atrazine	C	—	8	7	6	6	9	8	9	8	9	8	7	9	9	9	9	4	6	6	7
Basis	**C**	**8**	**8**	**8**	**—**	**6**	**7**	**8**	**6**	**9**	**9**	**9**	**—**	**9**	**6**	**8**	**9**	**5**	**8**	**—**	**—**
Canopy + 2,4-D[b]	S	4	4	4	4	4	8	8	8+	9	9	5	7	9	9	8	9	5	7	7+	7
Canopy EX + 2,4-D[b]	**S**	**4**	**4**	**4**	**4**	**4**	**9**	**8**	**8**	**9**	**9**	**6**	**8**	**9**	**9**	**8**	**9**	**5**	**8**	**7+**	**8**
Clarity, Banvel[c]	C&S	0	0	0	0	0	9	7	7	7	9	0	8	9	9	9	9	8	9	7+	9
Expert	**C**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**8**	**9**	**9**	**9**	**7**	**9**	**9**	**8**	**9**	**6**	**7**	**7**	**4**
Extreme	S	9	9	9	9	9	9	8+	7+	9	7+	9	—	9	9	9	9	6	7	7	7
FieldMaster	**C**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**8**	**9**	**9**	**9**	**7**	**9**	**9**	**8**	**9**	**6**	**7**	**7**	**4**
glyphosate[d]	C&S	9	9	9	9	8	9	7	7	8	7	9	5	8	7	8	7	5	6	5	6
glyphosate[e]	**C&S**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**8**	**9**	**8**	**9**	**6**	**9**	**9**	**9**	**8**	**6**	**7**	**7**	**7**
Gramoxone Inteon	C&S	7	9	7	7	6	9	8	6	7	6	8	5	8	8	7	6	3	6	4	7
Gramoxone Inteon + atrazine	**C**	**9**	**9**	**8**	**8**	**8**	**9**	**9**	**9**	**9**	**9**	**9**	**7**	**9**	**9**	**9**	**9**	**4**	**7**	**6**	**8**
Marksman	C	9	9	8	5	5	9	9	9	9	9	5	6	9	9	9	9	8	9	7	9
Sencor	**C&S**	**8**	**—**	**7**	**5**	**4**	**9**	**8**	**6**	**8**	**8**	**5**	**—**	**7**	**7**	**6**	**8**	**3**	**5**	**6**	**5**
Valor SX	S	—	—	—	0	—	9	7	0	8	0	0	—	8	5	5	0	0	0	0	0
Valor XLT + 2,4-D[b]	**S**	**4**	**4**	**4**	**—**	**—**	**8**	**8**	**8+**	**9**	**9**	**5**	**7**	**9**	**9**	**8**	**9**	**6**	**8**	**7**	**8**

9 = excellent, 8 = good, 7 = fair, 6 = poor, < 5 = unsatisfactory, — = no information available.
[a]Labeled for burndown applications in corn (C) or soybean (S).
[b]Soybean herbicide applications require a 7-day interval between planting and application for 1 pt or less and a 30-day interval for applications of 1 to 2 pt or more.
[c]Soybean herbicide applications require a 14-day interval between planting and application for 8 fl oz or less and a 28-day interval for applications of 8 to 16 fl oz or more.
[d]Glyphosate rate 0.375 lb a.e. (see Table 8 for a listing of glyphosate formulations).

Table 10. Control of perennial grass and legume sods before no-till crop production

Herbicide	Rate/acre	Alfalfa	Blue-grass	Brome, smooth	Clover, red	Fescue, tall	Orchard-grass	Quack-grass	Timothy
glyphosate, fall	1.5 lb a.e.[a]	**8**	**9+**	**9**	**9**	**9**	**9**	**9**	**9**
glyphosate, fall	0.75 lb a.e.[a]	7	**9**	7	7	7	**8**	**9**	**9**
+ 1 pt 2,4-D		**8**	9	6	**9**	6	7	**8**	**8**
+ 0.5 pt Banvel		**8**	**9**	6	**9**	6	7	**8**	**8**
+ 1 pt Banvel		**9**	9	6	**9**	6	7	**8**	**8**
glyphosate, fall + spring	0.75/0.75 lb a.e.[a]	**8**	**9+**	**9+**	**9**	**9**	**9**	**9**	**9**
glyphosate, spring	1.5 lb a.e.[a]	6	9	8	7	7	7	9	8
glyphosate, spring	0.75 lb a.e.[a]	5	**8**	6	5	6	6	7	7
+ 1 pt 2,4-D		7	**8**	5	**8**	5	5	6	7
+ 0.5 pt Banvel		**8**	**8**	5	**9**	5	5	6	7
Gramoxone Inteon, spring	4 pt	N	6	4	6	7	4	4	6
Gramoxone Inteon, spring	2 pt	N	5	N	5	5	N	N	5
+ 2 lb atrazine		5	9	7	**8**	**8**	7	7	**8**

9 = excellent, **8** = good, 7 = fair, 6 = poor, 5 or 4 = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.

[a]See Table 8 for a listing of glyphosate formulations and product rates.

Table 11. Corn herbicides: Preplant or preemergence rates per acre

Herbicide	Unit	1% OM sandy loam[a]	1–2% OM silt loam[b]	3–4% OM silty clay loam[c]	5–6% OM silty clay[c]
Atrazine 4L	qt	2.0	2.0	2.0	2.0
Atrazine 90DF	lb	2.2	2.2	2.2	2.2
Balance PRO 4SC	fl oz	No	1.88–3.0[d]	2.25–3.75	2.25–3.75
Banvel 4S	pt	No[e]	No[e]	1.0	1.0
Bicep II Magnum 5.5L	qt	1.3	1.6	2.1	2.6
Bicep Lite II Magnum 6L	qt	0.9	1.1	1.5	1.9
Bullet 4L	qt	2.5	3.0	4.0	4.5
Callisto 4SC	fl oz	6–7.7	6–7.7	6–7.7	6–7.7
Clarity 4S	pt	No[e]	No[e]	1.0	1.0
Define 4SC	fl oz	15	19	22	25
Degree 3.8CS	pt	2.25–3.25[g]	3.25–4.25	4.25–5	4.25–5
Degree Xtra 4.04CS	qt	2.9[g]	2.9–3.7	3.2–3.7	3.2–3.7
Dual II Magnum 7.64EC	pt	1.0	1.33	1.67	2.0
Expert 4.88SC	qt	2.5–3.7	3–3.75	3–3.75	3–3.75
FieldMaster 4.06S	qt	3.5–5	4–5	4–5	4–5
FulTime 4L	qt	2.5[g]	3.0	4.0	5.0
G-Max Lite 5L	pt	2.0	2.5	3.0	3.5
Guardsman Max 5L	pt	3.0	4.0	4.6	4.6
Harness 7EC	pt	1.5[g]	2.0	2.5	2.75
Harness Xtra 5.6L	qt	1.4[g]	2.0	2.5	3.0
Hornet WDG 68.5WDG	oz	4.0	5.0	5.0	5.0
Keystone 5.25L, Breakfree ATZ	qt	2.2[g]	2.4	2.6	3.1
Keystone LA 5.5L, Breakfree ATZ Lite	qt	1.6[g]	1.8	1.9	2.7
Lexar 3.7L	qt	3	3	3.5	3.5
Lumax 3.95L	qt	2.5	2.5	3.0	3.0
Marksman 3.3L	pt	No[e]	No[e]	3.5	3.5
Micro-Tech 4CS	qt	2.0	2.25	2.75	3.25
Outlook 6EC	fl oz	12–14	14–16	18–21	18–21
Partner 65WG	lb	3.0	3.5	4.0	5.0
Princep or simazine 90DF	lb	2.2	2.6	3.3	4.0
Prowl or Pendimax 3.3EC	pt	2.0	3.0	4.0	4.8
Prowl H_2O 3.8CS	pt	2.0	3.0	4.0	4.0
Pursuit Plus[h] 2.9EC	pt	2.5	2.5	2.5	2.5
Python 80WDG	oz	0.8[f]	1.0[f]	1.25	1.33
Radius 4SC	fl oz	7–10	9–16	14–28	19–28
SureStart 4.16SE	pt	No	1.5–1.75	1.75 pt	2.0
Surpass 6.4E, Breakfree	pt	1.5[g]	2.0	2.5	3.0
TopNotch 3.2CS	qt	2.0[g]	2.25	2.5	3.0

OM = organic matter in the soil.
No = not labeled for use on this soil type.

[a]Characteristic of most sandy soils in Illinois.
[b]Characteristic of many Illinois soils south of Interstate 70.
[c]Characteristic of many "prairie soils" in northern Illinois.
[d]To use these rates the OM needs to be greater than 1.5%.
[e]If planted to no-till corn, may use 0.5 pt Banvel or 2 pt Marksman.
[f]May cause crop injury on this soil.
[g]Do not use if groundwater is within 30 ft of surface.
[h]Use only with Clearfield (CL) corn hybrids.

Table 12. Corn herbicides: Grass and nutsedge control ratings

	Annuals								Perennials				
Herbicide	Barnyardgrass	Crabgrass	Cupgrass, woolly	Foxtail, giant	Foxtail, yellow	Panicum, fall	Sandbur	Shattercane	Johnsongrass	Muhly, wirestem	Nutsedge, yellow	Quackgrass	Corn response
Soil-applied													
Atrazine	7+	5	4	7	7	N	6	N	N	N	6	7	0
Define	9	9	7	9	9	9	7	5	N	N	7	N	1+
Degree, Harness	9	9	7+	9	9	9	7	5	N	N	8	N	1+
Dual II Magnum	9	9	7	9	9	9	6	5	N	N	8	N	1
Outlook	9	9	7	9	9	9	6	5	N	N	7+	N	1+
Micro-Tech	9	9	7	9	9	9	6	5	N	N	7+	N	1+
Surpass, Breakfree, Top-Notch	9	9	7+	9	9	9	7	5	N	N	8	N	1+
Pendimax/Prowl	8+	8+	8	8+	9	8+	8	7	N	N	N	N	1+
Balance PRO	8	7	8	8	6	8	6	5	N	5	N	N	2
Radius	9	9	8	9	9	9	6	5	N	5	3	N	2
Simazine	8	7	4	8	8	7	6	4	N	6	4	6	0
	. . . . . *See Table 13 for maximum grass sizes*												
Postemergence													
Accent or Celebrity Plus	8+	5	8	8+	8+	8+	8	9	8+	7	6	8+	1+
Basis	8	6	5	8	8	7+	6	8	4	5	4	4	2
Beacon	4	4	N	6	5	7+	6	9	7+	5	6	8	2
Equip	8+	5	5	8	7	8	7	9	8	7+	4	8	2
Option	8+	5	6	8+	8	8+	7	9	8+	8	N	8	2
Steadfast	8+	6	7	8+	8	8+	8	9	8	6	5	8	2
Steadfast ATZ	8+	7	7	8+	8	8+	8	9	8	6	5	8	2
Impact	7	7	5	7+	7	6	N	N	N	N	N	N	1
Lightning[a]	8	7+	8+	8+	8	8	8	9	7	5	6	5	1+
Atrazine + oil	7	5	6	7	7	4	6	N	N	5	7	6	1
Liberty[b]	7	6	8	8	7	8	7	7+	5	6	6	6	1
glyphosate[c,d]	9	9	9	9	9	9	9	9	9	8+	7	8+	1
Spirit	N	N	N	4	4	4	4	8+	6	N	5	6	1+
NorthStar	N	N	N	4	4	4	4	8+	6	N	5	6	1+
Permit	N	N	N	N	N	N	N	N	N	N	9	N	1
Yukon	N	N	N	N	N	N	N	N	N	N	9	N	1+
Laddok S-12	N	N	N	N	N	N	N	N	N	N	8	N	1
Callisto	N	7	N	N	N	N	N	N	N	N	N	N	1+

9 = excellent, 8 = good, 7 = fair, 6 = poor, 5 or 4 = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.
Corn response: 0 = minimal, 1 = possible, 2 = probable, 3 = serious.
[a]Use only with Clearfield (CL) corn hybrids.
[b]Use only with Liberty Link (glufosinate-resistant) corn hybrids.
[c]Use only with glyphosate-resistant corn hybrids.
[d]See Table 8 for a listing of glyphosate formulations registered for use on glyphosate-resistant corn hybrids.

Table 13. Corn "post-grass" herbicides: Maximum weed sizes

		Annual grasses											Perennial weeds				
Herbicide	Rate / A	Barnyardgrass	Corn[a], volunteer	Crabgrass	Cupgrass, woolly	Foxtail, giant	Foxtail, yellow	Panicum, fall	Sandbur	Shattercane	Signalgrass, broadleaf	Johnsongrass, seedling	Johnsongrass	Quackgrass	Nutsedge, yellow	Thistle, Canada	Wirestem, muhly
		Maximum size (height or length of lateral) in inches for given rate.															
Accent	⅔ oz	4	—	—	4	4	4	4	3	12	2	12	18	10	—	—	—
Basis	⅓ oz	2	—	—	1	2	2	2	—	4	—	—	—	—	—	—	—
Beacon	0.76 oz	—	—	—	—	2*	2*	2	4*	12	—	12	16	8	4*	9*	—
Callisto	3.0 fl oz	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Celebrity Plus	4.7 oz	4	—	—	4	4	4	4	3	12	2	12	18	10	—	—	—
Equip	1.5 oz	4	—	2	2	3	3	3	2	8	2	8	8	6	—	3	6
Impact	0.75 fl oz	4	—	3	3*	4	3*	3*	—	—	3*	4*	—	—	—	6*	—
NorthStar	5.0 oz	—	—	—	—	3*	3*	3*	4*	12	—	12*	16*	8*	4*	6*	—
Option	1.5 oz	4	—	2	2	3	3	3	2	12	3	8	16	10	—	—	10
Resolve	1 oz	2	—	½	1	2	2	2	—	4	2*	2*	—	2*	2*	3*	—
Spirit	1.0 oz	—	—	—	—	—	3*	—	—	12	—	12*	16*	8*	—	9*	—
Steadfast	0.75 oz	4	—	1	3	4	4	4	2	6	2	12	12	8	4*	4*	4*
Steadfast ATZ	14 oz	4	—	1	3	4	4	4	2	6	3	8	12	8	4*	4*	4*
Herbicides requiring specially designated corn hybrids																	
Liberty (LL)	28 fl oz	—	—	—	4	3	—	2	—	—	2	2	—	—	—	—	—
	34 fl oz	4	12	4[b]	8	8	4[b]	4	3[b]	8	5	8	—	—	—	—	—
Lightning (CL)	1.28 oz	3	12	3	3	6	3	3	1	8	8	8	8*	3*	3*	3*	—
glyphosate[c]	0.75 lb a.e.	6	20	12	12	20	20	12	12	20	6	18	12	8	6	—	> 8
(RR)	1.13 lb a.e.	9	20	12	12	20	20	12	12	20	9	24	12	8	6	—	> 8

— = Maximum size not specified on label.
* Suppression or partial control.
[a] Volunteer corn that is not resistant to the herbicide.
[b] Prior to tillering.
[c] Table 8 lists glyphosate formulations registered for use on glyphosate-resistant corn hybrids. Maximum weed heights listed above are from the Roundup Weathermax label. Check individual glyphosate labels for maximum weed heights.

Table 14. Corn herbicides: Broadleaf weed–control ratings

Herbicide	Burcucumber	Cocklebur	Jimsonweed	Kochia	Lambsquarters	Morninggiories, annual	Nightshade, eastern black	Pigweeds	Ragweed, common	Ragweed, giant	Sida, prickly	Smartweeds	Sunflower, wild	Velvetleaf	Waterhemp	Corn response
Soil-applied																
Atrazine[a]	6	8	9	9	9	8+	9	9	9	8	9	9	8	7	9	0
Balance PRO	7	4	8	8+	9	4	8+	9	9	6	7	8	6	9	9	2
Callisto	N	4	8	6	9	6	9	8+	7	7	7	8+	8	9	9	0
Hornet WDG	N	8	8	8+	9	7	7+	9	8+	7+	7+	8+	9	8+	N	1
Marksman	6	8	8	7	9	8	8	9	9	7+	7	9	8	8	9	2+
Python[b]	N	7	7+	8+	8+	5	7+	9	7+	5	8	8+	7+	8	N	1
Simazine[a]	6	8	9	9	9	8	9	9	9	7	9	9	8	7	8+	0
	..... *See Table 15 for maximum weed sizes*															
Postemergence																
Contact																
Aim	N	6	6	8	8	8	8+	8+	6	4	7	5	4	9	7	2
Atrazine[a] + oil	8	9	9	9	9	9	9	9	9	8	8+	9	9	8	9	1
Buctril	7	9	9	8+	9	8	9	6	8+	8	4	8+	9	8	6	2
Buctril + atrazine	8+	9	9	9	9	9	9	9	9	9	8	9	9	8+	9	2
Laddok S-12	6	9	9	8	8+	8	8	8+	9	8+	8	9	9	9	8+	1
Liberty[c]	7	9	9	8+	8	8	8+	8	8+	8	8	8+	9	8	8	1
Resource	5	7	7	4	7	5	4	7	7	6	7	5	4	9	7	1+
Plant-growth regulator (PGR)[d]																
2,4-D	N	9	7	7	9	9	7	9	9	8+	8	6	8	8	8	2+
Banvel or Clarity	7	9	8+	8+	9	9	8	9	9	9	8	9	8+	8	9	1+
Distinct/Status	7	9	8+	8+	9	9	8	9	9	9	8	9	9	8	9	1+
Marksman	8	9	9	8+	9	9	9	9	9	9	9	9	9	8+	9	1
Stinger	N	9	8	N	N	N	7	N	9	9	N	7	9	N	N	0
HPPD inhibitor																
Callisto + atrazine	N	8+	9	6	9	7	9	9	8	8+	6	9	8	9	9	1+
Impact + atrazine	8	8+	9	8	9	6	9	9	9	8+	6	8	8+	8+	9	1
Acetolactate synthase (ALS)[b]																
Accent	7+	6	8	7	5	7	N	8+	4	N	N	8	4	5	N	1+
Basis	N	7	4	7	8	5	N	8+	5	N	N	8	8	8	N	2
Beacon	8+	8	8	8	6	6	8	8+	9	9	7	8	8+	7+	N	2
Equip	8	9	8+	8	8+	6	9	9	8+	8	7	8	9	8	N	2
Lightning[c]	6	9	8+	8	8+	8	9	9	7	7	8	8+	9	8+	N	1+
Option	7	6	8	N	7	6	9	8+	7	6	N	N	8	8	N	2
Permit	5	9	7	7	4	6	4	9	8+	8	7	7+	9	8+	N	1
Spirit	8+	8+	8+	8	7	6	8	8+	9	9	7	8+	9	8	N	1+
Steadfast	5	6	7	6	6	6	N	8+	5	N	N	8	7	7	N	2
Steadfast ATZ	6	8	8	7	9	7	7+	9	8+	7+	6	9	8	8	7	2

Table 14. Corn herbicides: Broadleaf weed–control ratings (cont.)

Herbicide	Burcucumber	Cocklebur	Jimsonweed	Kochia	Lambsquarters	Morningglories, annual	Nightshade, eastern black	Pigweeds	Ragweed, common	Ragweed, giant	Sida, prickly	Smartweeds	Sunflower, wild	Velvetleaf	Waterhemp	Corn response
ALS + PGR																
Celebrity Plus	8	8+	8+	8+	8+	8+	8	9	8+	8	7	9	8	7	9	1+
Hornet	5	9	8	7	7	7	7	8	9	8+	7	8+	9	8+	N	1
NorthStar	8+	9	8+	8+	8+	8	8+	9	9	9	7	9	9	8+	8	1+
Yukon	6	9	8	8	8+	8	7+	9	9	8	7	8	9	8+	8	1+
EPSP																
glyphosate[f,g]	7+	9	9	8+	8+	6	8	9	8	8	7	8	9	8	9	1

9 = excellent, 8 = good, 7 = fair, 6 = poor, 5 or 4 = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.
Corn response: 0 = minimal, 1 = possible, 2 = probable, 3 = serious.
[a]Will not control triazine-resistant weed biotypes.
[b]Will not control ALS-resistant weed biotypes.
[c]Use only with Liberty Link (glufosinate-resistant) corn hybrids.
[d]Crop response ratings increase if an NIS or a COC is added.
[e]Use only with Clearfield (CL) corn hybrids.
[f]Use only with glyphosate-resistant corn hybrids.
[g]See Table 8 for a listing of glyphosate formulations registered for use on glyphosate-resistant corn hybrids.

For herbicide ratings for tank mixes or premixes, see the component parts:

Premix	Grass	Broadleaf
Bicep II Magnum	Dual II Magnum	atrazine
Bicep Lite II Magnum	Dual II Magnum	atrazine
Bullet	Micro-Tech	atrazine
Degree Xtra	Degree	atrazine
Expert	Dual II Magnum	atrazine + glyphosate
FulTime	TopNotch	atrazine
G-Max Lite	Outlook	atrazine
Guardsman Max	Outlook	atrazine
Halex GT	Dual II Magnum	glyphosate + Callisto
Harness Xtra	Harness	atrazine
Keystone, Breakfree ATZ	Surpass	atrazine
Keystone LA, Breakfree ATZ Lite	Surpass	atrazine
Lexar	Dual II Magnum	atrazine + Callisto
Lumax	Dual II Magnum	atrazine + Callisto
Radius	Define	Balance PRO
SureStart	Surpass	Hornet

Table 15. Corn "post-broadleaf" herbicides: Maximum broadleaf weed sizes

Herbicide (rate)	Burcucumber	Cocklebur, common	Jimsonweed	Kochia	Lambsquarters	Morningglories, annual	Nightshade, eastern black	Pigweeds	Ragweed, common	Ragweed, giant	Smartweeds	Sunflower, wild	Velvetleaf	Waterhemp
Translocated herbicides	*Maximum size (height) in inches or leaf number (L)*													
2,4-D amine[a] (1 pt)	—	6	3*	2*	4	6	2*	4	6	6	2*	2	2	4
Accent (0.67 oz)	3	—	3	—	—	3	—	4	—	—	4	—	—	—
Banvel or Clarity[a] (16 oz)	4	4	4	4	4	4	4	4	4	4	6	2	2	4
Basis (0.33 oz)	—	—	—	—	3	—	—	3	—	—	3	3	3	—
Beacon (0.38 oz)	—	4	4	—	—	—	4	3	6	6	2	6	—	—
Beacon (0.76 oz)	4	4	4	4	1.5*	1.5*	4	4	9	9	4	9	4	—
Callisto (3 fl oz)	—	5	5	5	5	5	5	5	5	5	5	5	5	5
Celebrity Plus (4.7 oz)	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Distinct[a] (4–6 oz)	4	4	4	4	4	4	4	4	4	4	6	2	2	4
Equip (1.5 oz)	4	6	4	3	4	2	4	4	4	4	4	6	4	—
Hornet WDG (3 oz)	—	6	6	2*	2*	2*	2*	2*	6	6	6	6	6	—
Hornet WDG (4 oz)	—	8	8	4*	4*	4*	4*	4*	8	8	8	8	8	—
Lightning[b] (1.28 oz)	—	8	3	3	3	3	3	8	3*	3	3	3	3	—
Marksman[a] (3.5 pt)	4	6	6	6	6	6	6	6	6	6	8	6	6	6
NorthStar (5 oz)	4	6	6	4	4	3*	6	5	9	9	4	9	4	4
Option (1.5 oz)	3	2	3	—	2	3*	4	3	2	3*	—	2	3	—
Permit (0.67 oz)	3*	9	—	3	2*	—	—	3	9	3	2	12	9	—
glyphosate[c,d] (0.75 lb a.e.)	12	24	12	12	12	3	6	18	12	12	6	18	6	6
glyphosate[c,d] (1.13 lb a.e.)	18	36	18	12	20	6	12	24	18	18	9	18	12	12
Resolve (1 oz)	—	3*	—	3	3*	3*	—	3	3*	—	3*	—	3*	—
Spirit (1 oz)	6	8	6	4	3	4*	5	4	9	9	6	12	6	—
Steadfast (0.75 oz)	4	4*	4	—	4*	4	—	4	—	—	4*	4	4*	2*
Steadfast ATZ (14 oz)	4	4	4	—	4	4	4	4	4	4	4	4	2	4*
Stinger (0.5 pt)	—	5L	5L	—	—	—	4L	—	5L	5L	—	5L	—	—
Yukon (4 oz)	12*	14	4	6	6	6	6	12	12	6	3	15	12	6
Contact herbicides														
Aim EW (0.5 fl oz)	—	—	—	—	3	3L	4	4	—	—	—	—	4	2
Atrazine[a] 4L (2 qt)	—	4*	4	—	6	4	4	6	4	4	4	—	2*	4
Basagran 4S (1.5 pt)	—	6	6	—	—	—	—	—	—	—	6	5	2	—
Basagran 4S (2 pt)	—	10	10	—	2*	4*	—	—	3	6	10	8	5	—
Buctril 2E (1 pt)	—	8	4	—	6	3	6	—	4	4	4	6	3	2
Buctril 2E (2 pt)	4	10	6	2	8	4	6	2	6	6	6	8	5	2
Buctril + Atrazine (1.5 pt)	—	8	4	2	6	3	4	2	4	6	4	8	3	2
Buctril + Atrazine (3.0 pt)	4	12	6	4	12	4	6	4	6	8	8	12	6	6
Impact (0.75 fl oz)	6	8	6	6	6	6*	6	6	6	8	3	8	8	6
Laddok S-12 (1.67 pt)	—	8	6	4	5	4	1	6	4	4	10	6	5	2
Laddok S-12 (2.33 pt)	3	8	8	4	8	6	1	6	5	6	12	8	8	4
Liberty[e] (28 fl oz)	3	3	3	2	2	3	3	2	3	3	3	3	3	2
Liberty[e] (34 fl oz)	8	8	8	6	6	7	8	6	8	8	8	8	6	6
Resource[f] (6 fl oz)	—	—	—	—	3L*	—	—	3L	3L	—	—	—	6L	—

Table 15. Corn "post-broadleaf" herbicides: Maximum broadleaf weed sizes (cont.)

— = Maximum size not specified on label.
* Suppression or partial control.
[a]No sizes given on label; weed sizes here are best estimates.
[b]Use only with Clearfield (CL) corn hybrids.
[c]Use only with glyphosate-resistant corn hybrids.
[d]Table 8 lists glyphosate formulations registered for use on glyphosate-resistant corn hybrids. Maximum weed heights listed above are from the Roundup Weathermax label. Check individual glyphosate labels for maximum weed heights.
[e]Use only with Liberty Link (glufosinate-resistant) corn hybrids.
[f]The Resource label indicates maximum weed size by leaf number, "L."

Table 16. Herbicide label statements: Interactions with organophosphate (OP) insecticides

	Soil-applied OP insecticides						Foliar OP insecticide,[a] applied	
	Counter 20CR				Aztec or Fortress			
Corn herbicide	Furrow	T-Band	Thimet	Lorsban	Furrow	Band	Days before	Days after
nicosulfuron and rimsulfuron								
Accent	No	UCI	UCI	UCI	Yes	Yes	7	3
Basis	No	UCI	UCI	UCI	Yes	Yes	7	3
Steadfast, Steadfast ATZ	No	UCI	UCI	UCI	Yes	Yes	7	3
Celebrity Plus	No	TCI	TCI	TCI	Yes	Yes	7	3
Resolve	No	UCI	UCI	UCI	Yes	Yes	7	3
primisulfuron and prosulfuron								
Beacon	No	UCI	TCI	TCI	TCI	TCI	10	7
NorthStar	No	UCI	TCI	TCI	TCI	TCI	10	7
Spirit	No	UCI	TCI	TCI	TCI	TCI	10	7
flumetsulam								
Hornet WDG, preemergence	No	No	No	TCI[b]	No[b]	TCI	10	10
Python	No	No	No	TCI[b]	No[b]	TCI	—	—
Hornet WDG, postemergence	No	No	No	TCI	TCI	TCI	10	10
SureStart	No	No	No	TCI[b]	Yes	Yes	10	10
imazethapyr and imazapyr								
Lightning[c]	Yes	Yes	Yes	TCI	Yes	Yes	—	—
Pursuit[c]	Yes	Yes	Yes	TCI	Yes	Yes	—	—
thifensulfuron								
Harmony GT XP	No	UCI	UCI	UCI	Yes	Yes	7	3
mesotrione								
Callisto[d]	No	No	Yes	No	Yes	Yes	7	7
Halex GT	UCI	UCI	UCI	UCI	Yes	Yes	7	7
Lexar[d]	No	No	Yes	TCI	Yes	Yes	7	7
Lumax[d]	No	No	Yes	TCI	Yes	Yes	7	7
halosulfuron								
Permit	No restrictions on label							
Yukon	No restrictions on label							
foramsulfuron and iodosulfuron								
Equip	No	No	No	TCI	Yes	Yes	7	7
Option	No	No	No	TCI	Yes	Yes	7	7

No = Do not use this herbicide on corn if this insecticide was previously applied in this manner.
Yes = This herbicide can be applied to corn if this insecticide was previously applied in this manner.
UCI = Using this herbicide on corn if this insecticide was previously applied in this manner may result in unacceptable crop injury.
TCI = Using this herbicide on corn if this insecticide was previously applied in this manner may result in temporary corn injury.
— = No information is available at this time.
[a]Foliar-applied OPs include Cygon, Diazinon, DiSyston, Imidan, Lorsban, and Malathion.
[b]Lorsban, Fortress, or Aztec should not be placed in-furrow if a flumetsulam herbicide is to be soil-applied.
[c]Use only Clearfield (CL) corn hybrids.
[d]Postemergence applications.

Table 17. Corn "post" herbicides: Adjuvant use plus application and use restrictions

Herbicide	Adjuvant and nitrogen	Rain-free period (hr)	Reentry interval (hr)	PHI (days)	Apply broadcast up to	Use drop nozzles
2,4-D amine	None	6–8	48	7	8"	8" to tassel
2,4-D ester	None	1–2	12	7	8"	8" to tassel
Accent	COC or NIS + NH_4	4	4	30	20"/V6	20" to 36"/V10
Aim EW	NIS or COC[a]	6	12	—	V8	V8 to V14
Atrazine	COC	1–2	12	21	12"	
Banvel	NIS[a] or NH_4[a]	4	24	—	24"[b] to 36"	Reduces drift
Basagran	COC + NH_4	4	12	12	Any size?	
Basis	NIS or COC + NH_4	4	4	30	6"/V2	
Beacon	COC or NIS + NH_4	4	12	45	4" to 20"	Splits 20" to tassel
Buctril	COC[d] or NIS[d]	1	12	45	pretassel	
Buctril + atrazine	COC[d] or NIS[d]	1	12	45	12"	
Callisto	COC + NH_4	1	12	45	30"/8-leaf	
Celebrity Plus	NIS + NH_4	4	12	72/32	4" to 20"/V6	20" to 24"
Clarity	NH_4 + COC[a, e] or NIS[a]	4	12	—	24"[b] to 36"	Reduces drift
Distinct	NIS + NH_4	4	12	72/32	4" to 24"	24" to 36"
Equip	MSO + NH_4	2	12	70/45	V4	V4 to V8
Halex GT	NIS + AMS	1	24	45	30"/V8	
Harmony GT XP	COC or NIS + NH_4	1	4	30	16"/V5	
Hornet WDG	NIS, MSO, or COC, ± NH_4 if dry	2	48	85	20"/V6	20" to 36"
Impact	MSO or COC + NH_4	1	12	45	See PHI.	
Laddok S-12	COC + NH_4	4[c]	48	21	12"	
Liberty[f]	AMS only	4	12	70/60	24"/V7	24" to 36"
Lightning[g]	NIS + NH_4	1	12	45	20"/V6	20" to PHI
Marksman	NIS or NH_4	4	48	—	5-leaf or 8"	
NorthStar	COC[h] or NIS + NH_4	4	12	60/45	4" to 20"/V6	20" to 36"[b]
Option	MSO + NH_4	2	12	70/45	V6	V6 to V8
Permit	COC or NIS + NH_4	4	12	30	layby (36")	
Pursuit[g]	COC or NIS + NH_4	1	12	45	See PHI.	
Resource	COC + NH_4	1	12	28	2- to 10-leaf	
glyphosate[i, j]	See label[k] (AMS optional)	1–2	4	7/50	30"/V8	30" to 48"[l]
Resolve	COC or NIS + NH_4	4	4	30	12"/V6	
Sencor	NIS or NH_4	—	12	60	pretassel	See tank-mix partner.
Shotgun	None	4	12	21	8"/4-leaf	8" to 12"
Spirit	COC or NIS + NH_4	4	12	60/40	4" to 20"/V6	20" to 24"/< tassel
Status	COC or NIS +NH_4	4	24	72/32	36"/V10	
Steadfast	COC or NIS + NH_4	4	4	30	20"/V6	
Steadfast ATZ	COC or NIS + NH_4	4	12	60	12"/V6	
Stinger	NIS optional	6	12	40	24"	
Yukon	NIS or COC, ± NH_4	4	12	30	24" or 36"[b]	Reduces drift
Harvest-aid use						
2,4-D	None	6–8	48	—	After dent	
glyphosate	See label[k] (AMS optional)	1–2	4	7	After black layer	
Gramoxone Inteon	NIS	½	24	7	After black layer	

COC = crop-oil concentrate, NIS = nonionic surfactant, NH_4 = ammonium fertilizer adjuvant (UAN or AMS), UAN = urea–ammonium nitrate (28-0-0), AMS = ammonium sulfate (spray grade 21-0-0), PHI = preharvest interval for grain harvest, shorter for silage, — = no information is available at this time.

Table 17. Corn "post" herbicides: Adjuvant use plus application and use restrictions (cont.)

[a] Allowed if arid or droughty conditions exist at application.
[b] Up to 24 inches if nearby soybeans are more than 10 inches tall or are blooming.
[c] Current label indicates rainfall soon after application may decrease the effectiveness.
[d] Adjuvants allowed if injury is acceptable.
[e] Use of oils (penetrants) may cause injury "if corn is > 5 inches tall."
[f] Use only with Liberty Link (glufosinate-resistant) corn hybrids.
[g] Use only with Clearfield (CL) corn hybrids.
[h] COC allowed only up to 12-inch-tall corn.
[i] Use only with glyphosate-resistant corn hybrids.
[j] Table 8 lists glyphosate formulations registered for use on glyphosate-resistant corn hybrids. Consult individual glyphosate labels for information on other glyphosate formulations.
[k] Some glyphosate formulations contain surfactants. Consult individual glyphosate labels for adjuvant use.
[l] POST-directed applications in glyphosate-resistant hybrids are labeled only for certain hybrids.

Table 18. Soybean herbicides: Preplant or preemergence rates per acre

Herbicide	Unit	1% OM sandy loam[a]	1–2% OM silt loam[b]	3–4% OM silty clay loam[c]	5–6% OM silty clay[c]
Authority First/Sonic 70DF	oz	6.45	6.45	8	8
Authority MTZ	oz	12–14	14–16	16–18	18–20
Boundary 6.5EC	pt	No	1.8–2.1	2.4–2.7	2.4–3.0
Canopy 75DG	oz	2.25-6	2.25-6	2.25-7	2.25-7
Canopy EX 29.5WDG	oz	1.1–3.3	1.1–3.3	1.1–3.3	1.1–3.3
Command 3ME	pt	2.00	2.00	2.67	2.67
Define 4SC	fl oz	8–10	10–12	10–14	10–14
Dual II Magnum 7.64EC	pt	1.0	1.33	1.67	2.0
Extreme 2.17L	pt	3.0	3.0	3.0	3.0
FirstRate 84WDG	oz	0.6	0.6	0.75	0.75
IntRRo 4EC	qt	2.0	2.25	2.75	3.0
Linex 4L	pt	1.0–1.25	1.0–2.0	2.0	2.0
Micro-Tech 4ME	qt	2.0	2.25	2.75	3.0
Outlook 6EC	fl oz	12–14	14–16	18–21	18–21
Partner 65DF	lb	3.0	3.5	4.0	4.5
Pendimax or Prowl 3.3EC	pt	1.5	2.0	3.6	3.6
Prefix 5.3EC	pt	2.0	2.0–2.5	2.5	2.5
Prowl H_2O 3.8CS	pt	1.5	2.5	3.0	3.0
Pursuit 2AS	fl oz	4.0	4.0	4.0	4.0
Pursuit 70DG	oz	1.44	1.44	1.44	1.44
Pursuit Plus 2.9EC	pt	2.5	2.5	2.5	2.5
Python 80WDG	oz	0.80	1.00	1.25	1.33
Scepter 70DG	oz	2.8	2.8	2.8[e,f]	2.8[e,f]
Sencor 75DF	lb	No[d]	0.50	0.75	1.00
Sequence 5.25L	pt	2.5–3.5	3.5–4.0	4	4
Treflan 4EC	pt	1.0	1.5	2.0	2.0
Valor SX 51WDG	oz	2.0–2.5	2.0–2.5	2.5	3.0

OM = percent organic matter in the soil.
[a] Characteristic of most sandy soils in Illinois.
[b] Characteristic of many Illinois soils south of Interstate 70.
[c] Characteristic of "prairie soils" in northern Illinois.
[d] May cause excess crop injury on these soils.
[e] Carryover injury to corn may occur on these soils unless Clearfield (CL) corn hybrids are planted.
[f] May not be suitable on these soils.

Table 19. Soybean herbicides (soil- or foliar-applied): Grass and nutsedge control ratings

	Annuals								Perennials				Volunteer crops		
Herbicide	Barnyardgrass	Crabgrass	Cupgrass, woolly	Foxtail, giant	Foxtail, yellow	Panicum, fall	Sandbur	Shattercane	Johnsongrass	Muhly, wirestem	Nutsedge, yellow	Quackgrass	Cereals, volunteer (wheat, oats, rye)	Corn, volunteer	Soybean response
Soil-applied															
Define*	8+	8	6	8	8	8	5	4	N	N	4	N	N	N	1
Dual II Magnum	**9**	**9**	7	**9**	**9**	**9**	6	5	N	N	**8**	N	N	N	1
Outlook	**9**	**9**	7	**9**	**9**	8+	6	5	N	N	7+	N	N	N	1
IntRRo	**9**	**9**	7	**9**	**9**	**9**	6	5	N	N	7+	N	N	N	1
Command 3ME	**9**	8+	7	**9**	8+	**9**	7	7	N	N	N	N	**9**	5	1
Pendimax/ Prowl	**9**	**9**	8+	**9**	**9**	**9**	**8**	7+	N	N	N	N	6	5	1+
Trifluralin	9	9	8+	9	9	9	8+	8	N	N	N	N	6	6	1+
	..... *See Table 20 for maximum grass sizes*														
Postemergence															
Assure II	8+	8+	8	**9**	7	**9**	**9**	**9**	**9**	7	N	8+	**9**	**9**	0
Extreme[a]	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	8+	7	8+	**9**	**9**	1+
FirstRate	N	N	N	N	N	N	N	N	N	N	7	N	N	N	1
Fusilade DX	8+	**8**	**8**	8+	**8**	8+	8+	**9**	**9**	8+	N	8+	**9**	**9**	0
Fusion	**9**	8+	8	**9**	**9**	**9**	8+	**9**	**9**	7	N	7	**9**	**9**	0
Poast Plus	**9**	**9**	**9**	**9**	**9**	**9**	**9**	8+	7+	7	N	7	7	**8**	0
Select/SelectMax	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**8**	N	**8**	7	**9**	0
Pursuit	7	7	5	**8**	7	7	6	8+	5	N	5	N	5	5	1+
Raptor	7	7	5	8+	**8**	**8**	7	**9**	6	N	5	N	6	7	2
glyphosate[a,b]	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	8+	7	**9**	**9**	**9**	0
Basagran	N	N	N	N	N	N	N	N	N	N	**8**	N	N	N	1
Classic	N	N	N	N	N	N	N	N	N	N	7+	N	N	6	1+

9 = excellent, 8 = good, 7 = fair, 6 = poor, 5 or 4 = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.

Soybean response: 0 = minimal, 1 = possible, 2 = probable, 3 = serious.

*Expect only early-season weed control on medium- and fine-textured soils.

[a]Use only with glyphosate-resistant soybean varieties.

[b]Table 8 lists glyphosate formulations registered for use on glyphosate-resistant soybean varieties.

Table 20. Soybean "post-grass" herbicides: Maximum grass sizes

		Annuals											Perennials[a]			
Herbicide	fl oz/A	Barnyardgrass	Corn[d], volunteer	Crabgrass	Cupgrass, woolly	Foxtail, giant	Foxtail, yellow	Panicum, fall	Sandbur	Shattercane	Signalgrass, broadleaf	Wheat, volunteer	Johnsongrass, seedling	Johnsongrass, rhizome	Quackgrass	Muhly, wirestem
		Maximum grass size in inches for given rate.														
Assure II	5–8[b]	6[c]	30	6[c]	—	8	4[c]	6	6	12	—	6	8	—	—	8
	10–12	—	—	—	—	—	—	—	—	—	—	—	—	24	10	8
Fusion	6–8[b]	—	24	—	—	8	4	—	—	12	—	—	8	—	—	—
	8–10[b]	4	—	4	4	8	4	6	4	—	4	6	—	12[2]	10[2]	—
	10–12[b]	—	—	—	—	—	—	—	—	—	—	—	—	18[1]	10[1]	12
Fusilade DX	6–8	—	24	—	—	—	—	—	—	12	—	6	8	12[2]	10[2]	—
	10–12[b]	3	—	2	4	6	4	6	4	—	4	—	—	18[1]	10[1]	12
Poast Plus	12	4	12	—	—	4	—	4	—	—	—	—	—	—	—	—
	24–30	8	20	6	8	8	8	8	3	18	8	—	8	12[2]	8[2]	—
	36	12	—	8	—	16	16	12	—	—	12	4	—	25[1]	8[1]	6
Pursuit	4	3*	—	3*	3*	6	3	*	—	8*	8*	—	8	12*	—	—
Raptor	5	5*	8	4*	4*	6	6	6	—	8	5	4	8	12*	8*	—
Select	4–5	4	12	4	—	4	4	4	—	10	4	—	6	—	—	—
	6–8	8	24	6	8	12	8	8	6	18	6	6	10	18[2]	—	—
	8–16	—	—	—	—	—	—	—	—	—	—	—	—	24	12	8
Herbicides requiring glyphosate-resistant soybean varieties																
		Maximum grass size in inches for given rate.														
glyphosate[e]	0.56 lb a.e.	3	12	6	6	12	12	4	12	12	3	6	12	12	8	> 8
	0.75 lb a.e.	6	20	12	12	20	20	12	12	20	6	12	18	12	8	> 8
	1.13 lb a.e.	9	20	12	12	20	20	12	12	20	9	18	24	12	8	> 8
Extreme	3.0 pt	6	—	12	12	18	18	12	—	18	8	18	12	12	—	—

— = Maximum size not specified on label.
*Suppression or partial control.
[a]Perennials usually require sequential applications for satisfactory control. See the label for more information.
[b]Use higher rate if tank-mixed with broadleaf herbicide, if the weather is dry, or if weeds have reached maximum size.
[c]For best results on these grasses, do not tank-mix with a broadleaf herbicide.
[d]Volunteer corn that is not resistant to the herbicide.
[e]Table 8 lists glyphosate formulations registered for use in glyphosate-resistant soybeans. Maximum weed heights listed above are from the Roundup Weathermax label. Check individual glyphosate labels for maximum weed heights.
[1]Only one application is required.
[2]Two applications are required.

Table 21. Soil-applied soybean herbicides: Broadleaf weed–control ratings

Herbicide	Burcucumber	Cocklebur, common	Jimsonweed	Kochia	Lambsquarters	Morningglories, annual	Nightshade, eastern black	Pigweeds	Ragweed, common	Ragweed, giant	Sida, prickly	Smartweeds	Sunflower, wild	Velvetleaf	Waterhemp	Soybean response
Soil-applied "grass"																
Define*	N	N	4	N	5	N	5	6	4	N	N	N	N	N	6	1
Dual II Magnum	N	N	4	N	6	N	**8**	**8**	5	N	N	N	N	N	7+	1
Outlook	N	N	4	N	6	N	**8**	**8**	5	N	N	N	N	N	7+	1
IntRRo	N	N	4	N	6	N	**8**	**8+**	5	N	N	N	N	N	7+	1
Pendimax/Prowl	N	N	N	7+	**8**	N	N	**8+**	N	N	N	4	N	6	**8**	1+
Trifluralin	N	N	N	7+	**8+**	N	N	**8+**	N	N	N	**4**	N	N	**8**	1+
Soil-applied "broadleaf"																
Command 3ME	N	6	**8**	**9**	**8+**	N	5	5	**8**	5	**8+**	**8**	4	**9**	5	1
Sencor[a]	N	6	7+	**8**	**9**	N	N	**9**	**8+**	5	**8**	**9**	6	**8**	**8**	2
Canopy	7	**8+**	7+	7+	**9**	7+	N	**9**	**8+**	7+	7	**9**	**8**	**8+**	5	2
Canopy EX[b]	7	**8+**	7+	7	**9**	7+	N	**9**	**8+**	7+	7	**9**	7+	**8**	N	1
Python[b]	N	7	**8**	**8+**	**8+**	6	7+	**9**	7+	5	**8**	**8**	7	**8**	N	1
FirstRate[b]	—	**8+**	**8+**	**8**	**8+**	**8**	4	**8+**	**9**	**8**	7	**8**	**9**	**8**	N	1
Linex[a]	N	6	5	6	**8+**	4	6	**9**	**8**	5	7	7	N	6	7	2
Pursuit[b]	5	7	7	**8**	**8**	7+	**9**	**9**	7	6	**8**	**8+**	**8**	**8**	N	1
Scepter[b]	7	**9**	**8**	5	**9**	7	**8**	**8+**	**8+**	**8**	**8+**	**8+**	**9**	7	N	1
Valor SX	N	4	7+	7+	**8+**	7	**8+**	**8+**	**8**	4	**8**	7	N	7+	**8+**	1+

9 = excellent, **8** = good, 7 = fair, 6 = poor, 5 or 4 = unsatisfactory, N = no control or not labeled, — = no information is available at this time. Boldface indicates acceptable control.

Soybean response: 0 = minimal, 1 = possible, 2 = probable, 3 = serious.

*Expect only early-season weed control on medium- and fine-textured soils.

[a]Will not control triazine-resistant weed biotypes.

[b]Will not control ALS-resistant weed biotypes.

For herbicide ratings for tank mixes or premixes, see the component parts:

Premix	Grass	Broadleaf
Authority First/Sonic	—	Authority + FirstRate
Authority MTZ	—	Authority + Sencor
Boundary	Dual Magnum	Sencor
Extreme	glyphosate	Pursuit
Gangster	—	Valor + FirstRate
Prefix	Dual Magnum	Reflex
Pursuit Plus	Prowl	Pursuit
Sequence	Dual Magnum	glyphosate
Valor XLT	—	Valor + Classic

Table 22. "Post-broadleaf" soybean herbicides: Weed-control ratings

Herbicide	Burcucumber	Cocklebur, common	Jimsonweed	Kochia	Lambsquarters	Morningglories, annual	Nightshade, eastern black	Pigweeds	Ragweed, common	Ragweed, giant	Sida, prickly	Smartweeds	Sunflower, wild	Velvetleaf	Waterhemp	Soybean response
Contact-postemergence	····· *See Table 23 for maximum weed sizes* ·····															
Basagran	N	9	9	7	7	5	N	N	7	7	8	9	8+	8+	N	1
Storm	6	8+	9	6	6	7+	7	9	8+	7+	7	9	7	7+	8+	2
Ultra Blazer	7	7	9	6	5	8	8+	9	8+	8	N	8+	6	6	8	2
Cobra	7	8+	9	7	6	7+	8+	9	9	8+	6	5	8	7	8+	2+
Phoenix	6	8	8+	6	5	6	8	8+	8+	8	5	5	7	6	8	1+
Reflex	6	7	8+	5	5	8	8	9	8	8	N	7+	7	6	7+	1+
Flexstar	7	8	9	6	6	8	8	9	8+	8+	N	8	7	8	8	2
Resource	5	7	7	4	7	5	4	7	7	6	7	5	4	9	7	1+
Systemic-postemergence	····· *See Table 23 for maximum weed sizes* ·····															
Acetolactate synthase (ALS)[a]																
Classic	8	9	8+	4	4	7	N	8+	8	7	N	8	9	8	N	1+
Harmony GT XP	N	6	6	5	8+	4	N	9	5	4	N	8+	6	8	N	2+
Synchrony XP[b]	8	9	8+	6	8+	7+	N	9	8	7+	N	9	9	8+	N	1
FirstRate	6	9	9	5	N	8	N	5	9	9	4	8+	9	8+	N	1
Pursuit	5	8+	8	7	6	7	8+	9	7	7	6	8+	8	8+	N	1+
Raptor	6	8+	8	7+	8	7+	9	9	7	8	6	8+	9	8+	N	2
Scepter	N	9	4	4	N	N	5	9	5	N	N	6	8	N	N	1
EPSP																
glyphosate[c,d]	8	9	9	8+	8+	7	8	9	8	8+	7	8	9	8	9	0
ALS + EPSP																
Extreme[c]	8	9	9	8+	8+	7	9	9	8	8+	7	8+	9	8+	8+	1+

9 = excellent, 8 = good, 7 = fair, 6 = poor, 5 or 4 = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.

Soybean response: 0 = minimal, 1 = possible, 2 = probable, 3 = serious.

[a]Will not control ALS-resistant weed biotypes.

[b]Use only with STS-designated soybean varieties or at 0.375 oz / A on non-STS soybeans.

[c]Use only with glyphosate-resistant soybean varieties.

[d]See Table 8 for a listing of glyphosate formulations registered for use on glyphosate-resistant soybean varieties.

Table 23. Soybean "post-broadleaf" herbicides: Maximum weed sizes and application rates

Herbicide	Rate	Burcucumber	Cocklebur, common	Jimsonweed	Kochia	Lambsquarters[a]	Morningglories, annual	Nightshade, eastern black	Pigweeds	Ragweed, common	Ragweed, giant	Sida, prickly	Smartweeds	Sunflower, wild	Velvetleaf	Waterhemp
ALS translocated[b]	*oz/A*	*Label weed height in inches*														
Classic 25DF	0.50	—	6	4	—	—	2[c]	—	2	—	—	—	2	5	—	—
Classic 25DF	0.75	6[c]	12	6	—	—	4[c]	—	4	4	6	—	4	8	6	—
FirstRate 84WDG	0.30	6[c]	10	4	—	—	4	—	—	8	10	—	6	12	6	—
Harmony GT XP 75DF	0.083	—	6[c]	4[c]	—	4	—	—	8	—	—	—	6	6[c]	6	—
Pursuit 70DG	1.44	—	8	3	3	2[c]	2	3	8	3[c]	3[c]	—	3	3	3	—
Raptor 1S	4–5	—	8	6	4	5	4	5	8	5[c]	5[c]	4[c]	5	8	8	—
Scepter 70DF	1.40	—	8	—	—	—	—	—	4	—	—	—	—	4	—	—
Synchrony XP	0.75	6[c]	8	5	3[c]	4	3	—	8	4	4	—	8	8	8	—
Other translocated																
Extreme (RR)	3.0 pt	12	18	6	12	8	4	12	18	9	9	—	6	18	5	12
glyphosate[d] (RR)	0.75 lb a.e.	12	24	12	12	12	3	6	18	12	4	—	6	18	6	6
glyphosate[d] (RR)	1.13 lb a.e.	18	36	18	12	20	6	12	24	18	6	—	9	18	12	12
Contact	*pt/A*	*Label weed height in inches*														
Basagran	1.0	—	4	4	—	1[c]	—	—	—	—	—	—	4	3	2	—
Basagran	2.0	—	10	10	—	2[c]	4[c]	—	—	3	6	4	10	8	6	—
Ultra Blazer	1.0	—	—	4	—	—	2	< 2	< 4	2	< 2	—	4	—	—	< 4
Ultra Blazer	1.5	—	2[c]	6	—	2[c]	4	2	4	3	3	—	6	—	—	4
Storm	1.5	—	6	6	—	2[c]	2	2	3	3	6	2	6	—	2	3
Cobra	0.5	—	4L	4L	—	—	—	4L	6L	6L	4L	—	—	—	—	6L
Cobra	0.78	4L	6L	4L	8L	—	2–4L[e]	6L	6L	8L	6L	4L	4L[c]	2L	4L[c]	6L
Phoenix	0.5	—	—	2	—	—	—	2	3	4	3	—	—	—	—	4
Phoenix	0.78	4	4	4	2	—	4	4	5	6	4	2	—	2	—	6
Flexstar	1.25	—	6L	8L	—	2L[c]	3–4L[e]	6L	6L	6L	6L	2L	6L	2L	4L	4L
Reflex	1.25	—	2L	6L	—	2L[c]	2–4L[e]	4L	4L	4L	4L	—	4L	—	2L	2L
Resource	0.38	—	—	—	—	3L[c]	—	—	3L	4L	—	3L	—	—	8L	—
Resource	0.50	—	3L[c]	4L	—	3L[c]	—	—	4L	6L	—	4L	—	—	10L	—

— = No information is available at this time.
[a]Lambsquarters control is erratic with many herbicides.
[b]ALS-resistant biotypes are not controlled by ALS herbicides.
[c]Suppression or partial control only; may need supplemental control, as with split applications.
[d]Table 8 lists glyphosate formulations registered for use on glyphosate-resistant soybean varieties. Maximum weed heights listed above are from the Roundup Weathermax label. Check individual labels for maximum weed heights.
[e]Size varies with morningglory species.

Table 24. Soybean "post" herbicides: Adjuvant use plus application and use restrictions

Herbicide	Adjuvants and nitrogen	Rain-free period (hr)	Reentry interval (hr)	Preharvest interval (days)	Feed/graze forage
No-till burndown					
2,4-D amine	None	6–8	48	NA	No
2,4-D ester	None	1–2	12	NA	No
Gramoxone Max	COC or NIS	0.5	12	NA	NA
glyphosate	AMS optional	0–2	4–12	NA	NA
Postemergence grass only[b]					
Assure II	COC or NIS; NH_4 optional	1	12	80	No
Fusilade DX	COC or NIS; NH_4 optional	1	12	Prebloom	No
Fusion	COC or NIS; NH_4 optional	1	24	Prebloom	No
Poast Plus	COC; NH_4 optional	1	12	75	Hay?
Select	COC or NIS; NH_4 optional	1	24	60	No
Select Max	COC or NIS + AMS	1	24	60	No
Postemergence broadleaf, contact					
Basagran	COC; NH_4 optional	4	48	30	Yes/30 days
Cobra	COC or NIS; check humidity	0.5	12	45	No
Phoenix	NIS or COC	2	12	45	No
Flexstar	MSO or COC + NH_4	1	24	Prebloom	No
Resource	MSO or COC; NH_4 optional	1	12	60	No
Storm	COC or NIS or NH_4	4	48	50	No
Ultra Blazer	COC, NIS, or NH_4	4	48	50	No
Postemergence broadleaf, systemic[b]					
Classic	NIS, COC, or MSO[a] + NH_4	1	12	60	No
FirstRate	NIS, COC, or MSO + NH_4	2	12	65	Yes/14 days
Harmony GT XP	NIS or COC[a] + NH_4	1	4	60	No
Pursuit	MSO, COC, or NIS + NH_4	1	12	85	No
Raptor	MSO, COC, or NIS + NH_4	1	4	Prebloom	No
Synchrony XP	NIS or COC + NH_4	1	12	60	No
glyphosate[c, d]	See label[e] (AMS optional)	1–2	4	14	Yes/PHI
Extreme[c]	NIS + NH_4[f]	1	48	85	No
Harvest-aid use					
Clarity	NH_4 + COC or NIS	4	12	14	No
Gramoxone Inteon	NIS or COC	0.5	24	15	No
glyphosate[d]	See label[e] (AMS optional)[e]	1–2	12	7	> 25 days

COC = crop-oil concentrate, MSO = methylated seed oil (specialized VOC), NIS = nonionic surfactant, NH_4 = ammonium fertilizer adjuvant = UAN or AMS; UAN = urea–ammonium nitrate (28-0-0), AMS = ammonium sulfate (spray grade 21-0-0); PHI = preharvest interval.

[a]Penetrant adjuvant allowed but reduces crop tolerance.

[b]Some tank mixes allow NIS or COC; see the tank-mix partner's label.

[c]Use only with glyphosate-resistant soybean varieties.

[d]Table 8 lists glyphosate formulations registered for use on glyphosate-resistant soybean varieties. Consult individual glyphosate labels for information on other glyphosate formulations.

[e]Some glyphosate formulations contain surfactants. Consult individual glyphosate labels for adjuvant use.

[f]Spray-grade AMS is the preferred nitrogen source.

Table 25. Corn "post" herbicides: Perennial broadleaf weed–control ratings

Herbicide	Corn stage	Rate per acre	Artichoke, Jerusalem	Bindweed, field or hedge	Dogbane, hemp	Horsenettle	Milkweed, common	Milkweed, honeyvine (climbing)	Morningglory, bigroot (wild sweet potato)	Pokeweed	Smartweed, swamp (devil's shoestring)	Thistle, Canada
2,4-D amine	8 in. to tassel[a]	1 pt	7	7	6	6	5	6	6	7	N	6
2,4-D ester	Preharvest	2 pt	**8**	**8**	6	7	7	7	7	**8**	6	7
Banvel, Clarity	8–36 in.[a]	0.5 pt	**8**	**8**	5	7	6	6	5	7	7	**8**
Distinct	10–24 in.	4 oz	**9**	**9**	6	7	7	7	6	**8**	**8**	**8**
Stinger	≤ 24 in.	0.5–0.67 pt	**9**	4	4	5	5	6	4	4	5	**9**
Hornet WDG	<V6/20 in.	3.0 to 5.0 oz	**8**	4	4	5	4	5	3	4	4	**8**
Accent + Banvel[b]	8–24 in.[a]	0.67 oz + 0.5 pt	7	7	7	7	7	**8**	5	6	6	**8**
Beacon	Pretassel[c]	0.76 oz	**8**	5	6	**8**	6	6	5	7	5	7
Beacon + Banvel[b]	4–24 in.[d]	0.38 oz + 0.5 pt	**8**	7	7	7	6	6	5	7	7	**8**
NorthStar	4–36 in.[c]	5 oz	**8**	6	7	**8**	6	6	5	**8**	7	6
Spirit	4–24 in.[c]	1.0 oz	**8**	5	6	7	6	6	5	7	5	7
Spirit + Banvel[b]	4–24 in.[d]	1.0 oz + 0.5 pt	**8**	7	7	**8**	7	6	5	**8**	7	**8**
Status	4–36 in.	5–10 oz.	**9**	**9**	6	7	7	7	6	**8**	**8**	**8**
Lightning[e]	≤ 20 in.[c]	1.28 oz	**8**	6	4	5	5	6	4	6	6	6
Permit + Banvel[b]	8–36 in.[a]	0.67 oz + 0.5 pt	7	6	7	**8**	**8**	6	5	**8**	7	**8**
glyphosate[f]	Pretassel	1–2% solution	**8**	**8**	**8**	**8**	**8**	7	6	**8**	**8**	**9**
glyphosate[g,h]	≤ 30 in.	0.75 lb a.e.	**8**	7	7	7	7	7	5	6	7	**8**
Liberty	≤ 24 in.	1.75 pt	7	6	6	6	6	5	N	6	N	5

9 = excellent, **8** = good, 7 = fair, 6 = poor, 5 or less = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.

[a]Use drop nozzles; do not spray over whorl of corn.

[b]Use only NIS as adjuvant.

[c]Use drop nozzles with Beacon, NorthStar, Lightning, or Spirit in corn more than 20 inches tall.

[d]Use drop nozzles if corn is more than 12 inches tall.

[e]Use only with Clearfield (CL) corn hybrids.

[f]Glyphosate used as a spot treatment in corn.

[g]See Table 8 for a listing of glyphosate formulations registered for use in glyphosate-resistant corn hybrids.

[h]Use only with glyphosate-resistant corn hybrids.

Table 26. Soybean "post" herbicides for partial control or suppression of perennial weeds

Herbicide	Artichoke, Jerusalem	Bindweed, field or hedge	Dock, curly	Dogbane, hemp	Horsenettle	Milkweed, common	Milkweed, honeyvine (climbing)	Morningglory, bigroot	Nutsedge, yellow	Pokeweed	Smartweed, swamp	Thistle, Canada
glyphosate[a,c] 0.56 lb a.e.	**8**	7	6	7	7	7	7	5	6	**8**	7	**8**
glyphosate[b,c] 1–2%	**8**	**8**	7	**8**	**8**	**8**	7	6	7	**9**	**8**	**9**
Classic[d]	7	7	6	N	5	6	7	N	7+	6	N	7
Synchrony XP[e]	7	7	6	N	5	7	7	N	7+	6	N	7
Pursuit	**8**	N	6	N	7	N	N	N	6	N	N	6
Extreme[a]	**8**	7	6	7	7	7	7	5	6	**8**	7	**8**
Raptor	**8**	6	N	N	N	N	N	N	6	N	N	7
Basagran[d]	7	5	N	N	5	N	N	N	**8**	N	N	**8**
Ultra Blazer[f]	6	6	N	N	6	6	N	5	N	N	N	6
Cobra[g]	6	6	N	N	6	6	N	6	N	N	6	6
Flexstar	6	6	N	N	6	N	6	N	5	N	N	6
FirstRate	N	N	N	N	N	N	N	N	7	N	N	7

9 = excellent, **8** = good, 7 = fair, 6 = poor, 5 or less = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.

[a]Use only with glyphosate-resistant soybean varieties.

[b]Spot treatment with glyphosate solutions on a spray-to-wet basis before bloom stage.

[c]See Table 8 for a listing of glyphosate formulations.

[d]Use either the high rate or a split application for this degree of control.

[e]Use only with STS (sulfonylurea-tolerant) soybean varieties at rates greater than 0.375 oz/A.

[f]Label specifies high rate and favorable environmental conditions required for suppression.

[g]Label specifies the use of COC and a maximum of 6-leaf stage for suppression.

3

Weed Control for Small Grains, Pastures, and Forages

Good weed control is necessary for maximum production of high-quality small grains, pastures, and forages in Illinois. When properly established, these crops usually can compete effectively with weeds, so the need for herbicide applications is minimized. However, weeds can sometimes become significant problems and warrant control. For example, wild garlic is considered the worst weed problem in wheat in southern Illinois. Because its life cycle is similar to that of winter wheat, wild garlic can establish itself with the wheat, grow to maturity, and produce large quantities of aerial bulblets by wheat harvest time. Economics often makes it necessary to control wild garlic in winter wheat to minimize dockage.

In pastures, woody and herbaceous perennials can become troublesome. Annual grasses and broadleaf weeds such as chickweed and henbit may cause problems in hay crops. By proper management, many of these weed problems can be controlled effectively.

Several herbicide labels carry the following groundwater warnings under either the environmental hazard or the groundwater advisory section: "X is a chemical that can travel (seep or leach) through soil and enter groundwater that may be used as drinking water. X has been found in groundwater as a result of its use as a herbicide. Users of this product are advised not to apply X where the soils are very permeable (that is, well-drained soils such as loamy sands) and the water table is close to the surface." Table 1 lists herbicides that carry this warning. A few labels also warn against contamination of surface water.

Small Grains

Good weed control is critical for maximum production of high-quality small grains. Often, problems with weeds may be dealt with before the crop is established. For example, some broadleaf weeds can be controlled effectively in the late fall with **2,4-D** or dicamba **(Banvel** or **Clarity),** or with glyphosate, after corn or soybean harvest, if seeding is not too late.

Tillage helps control weeds. Although generally limited to preplant or postharvest operations, tillage can destroy many annual weeds and help suppress certain perennials. Good cultural practices such as proper seeding rate, optimal soil fertility, and timely planting help to ensure the establishment of an excellent stand and a crop that is better able to compete with weeds.

Winter annual grasses such as downy brome and cheat are very competitive in winter wheat. Illinois wheat producers are often limited to preplant tillage operations for control of these species, as few herbicides have label clearances for annual grass control in winter wheat. If there is a severe infestation of downy brome or cheat, planting an alternative crop or spring crop may be best for that field.

A decision to use postemergence herbicides for broadleaf weed control in small grains should be based on several considerations:

1. *Nature of the weed problem.* Identify the species present and consider the severity of the infestation. Also note the size of the weeds. Weeds are usually best controlled while small.

The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.

Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.

2. *Stage of the crop.* Most herbicides are applied after full-tiller until the boot stage. Do not apply herbicides from the boot stage to the hard-dough stage of small grains (see Figure 1 for a description of growth stages of small grains).
3. *Herbicide activity.* Determine crop tolerance and weed susceptibility to herbicides by referring to Tables 2 and 3. The lower rates in Table 3 are for more easily controlled weeds and the higher rates for the more difficult-to-control species. Tank mixes may broaden the weed spectrum and thereby improve control; check the herbicide label for registered combinations.
4. *Presence of a legume underseeding.* Usually 2,4-D ester formulations and certain other herbicides listed in Table 3 should not be applied because they may damage the legume underseeding.
5. *Economic justification.* Consider the treatment cost in terms of potential benefits, such as the value of increased yield, improved quality of grain, and ease of harvesting the crop.

Table 3 outlines current suggestions for weed-control options in wheat and oats, the two small grains most commonly grown in Illinois. Please refer to Table 4 for grazing-restriction information concerning herbicides used in small grains. Always consult the herbicide label for specific information about the use of a given product.

For annual broadleaf weeds, postemergence herbicides such as **2,4-D, Aim, Banvel** or **Clarity, Buctril** (bromoxynil), and **MCPA** can provide good control of susceptible species (Table 2). Herbicides must be applied during certain growth stages of the crop to avoid crop injury and for optimal weed control.

Some perennial broadleaf weeds may not be controlled satisfactorily with the low herbicide rates used in small grains, and higher rates are not advisable because they can cause serious injury to crops. To control perennial weeds, translocated herbicides such as **2,4-D, Banvel, Clarity,** or **glyphosate,** in combination with tillage after small-grain harvest or after soybean harvest but before establishing small grains, may be the best approach.

Stinger (clopyralid) may be used to control broadleaf weeds in wheat, oats, and barley. Stinger controls Canada thistle, as well as a number of annual broadleaf weeds (Table 2).

Wild garlic continues to be a serious weed problem in winter wheat. **Harmony GT XP** (thifensulfuron), applied in the spring at 0.5 to 0.6 ounce of 75DF per acre, effectively controls wild garlic aerial bulblets and some underground bulbs as well. **Harmony Extra XP** also helps control chickweed, henbit, common lambsquarters, smartweed, and several species of mustard. See Tables 2 and 3 for more information on controlling weeds in small grains.

Glyphosate may be used as a preharvest treatment in wheat for control of annual and certain perennial weed species. Applications should be made only after the hard-dough stage of the grain (30 percent or less grain moisture) and at least 7 days before harvest.

Review of Wheat Stages According to Feekes' Scale

Seedling

Stage 1. The coleoptile, a protective sheath that surrounds the shoot, emerges. The first leaf emerges through the coleoptile, and other leaves follow in succession from within the sheath of the previously emerging leaf.

Tillering

Stages 2 to 3. Tillers (shoots) emerge on opposite sides of the plant from buds in the axils of the first and second leaves. The next tillers may arise from the first shoot at a point above the first and second tillers or from the tillers themselves. This process is repeated until a plant has several shoots.

Stages 4 to 5. The leaf sheaths lengthen, giving the appearance of a stem. The true stems in both the main shoot and the tillers are short and concealed within the leaf sheaths.

Jointing

Stage 6. The stems and leaf sheaths begin to elongate rapidly, and the first node (joint) of the stem is visible at the base of the shoot.

Stage 7. The second node (joint) of the stem is visible. The next-to-last leaf is emerging from within the sheath of the previous leaf but is barely visible.

Stage 8. The last leaf, the "flag leaf," is visible but still rolled.

Stage 9. Preboot stage. The ligule of the flag leaf is visible. The head begins to enlarge within the sheath.

Stage 10. Boot stage. The sheath of the flag leaf is completely emerged and distended due to the enlarging but not yet visible head.

Heading

Stages 10.1 to 10.5. Heads of the main stem usually emerge first, followed in turn by heads of the tillers in order of their development. Heading continues until all heads are out of their sheaths. The uppermost internode continues to lengthen until the head is raised several inches above the uppermost leaf sheath.

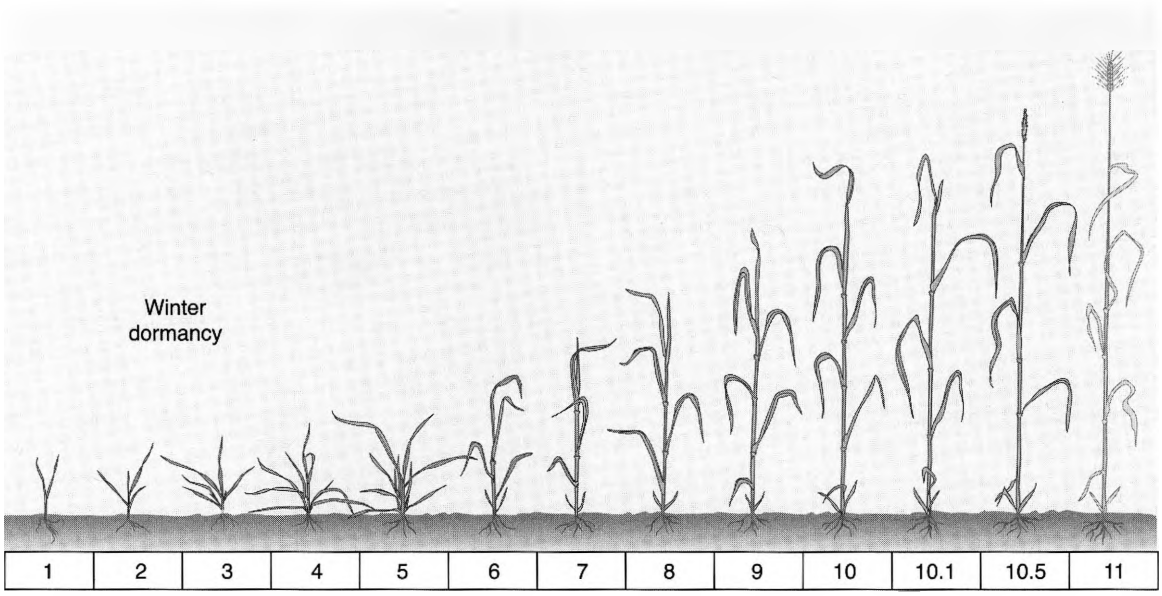

Figure 1. Growth stages of small grains (wheat shown). Numbers shown represent growth stages according to Feekes' scale.

Flowering

Stages 10.5.1 to 10.5.3. Flowering progresses in order of head emergence. Unpollinated flowers result in no kernels.

Stage 10.5.4. Premilk stage. Flowering is complete. The inner fluid is abundant and clear in the developing kernels of the flowers pollinated first.

Ripening

Stage 11.1. Milk stage. Kernel fluid is milky white from the accumulating starch.

Stage 11.2. Dough stage. Kernel contents are soft and dry (doughy) as starch accumulation continues. The plant leaves and stems are yellow.

Stage 11.3. The kernel is hard, difficult to divide with the thumbnail.

Stage 11.4. The kernel is ripe for cutting and fragments when crushed. The plant is dry and brittle.

Grass Pastures

Unless properly managed, broadleaf weeds can become a serious problem in grass pastures. They can compete directly with forage grasses and reduce the nutritional value and longevity of the pasture. Certain species, such as white snakeroot and poison hemlock, are also poisonous to livestock and may require special consideration.

Perennial weeds are of great concern in pasture management. They can exist for many years, reproducing from both seed and underground parent rootstocks. Occasional mowing or grazing helps control certain annual weeds, but perennials can grow back from underground root reserves unless long-term control strategies are implemented.

Certain biennials can also flourish in grass pastures. The first year, they exist as a prostrate rosette so that even close mowing does little to control their growth. The second year, biennials produce a seed stalk and a deep taproot. If these weeds are grazed or mowed at this stage, root reserves can enable the plant to grow again, thereby increasing its chance of surviving to maturity.

In general, the use of good cultural practices such as maintaining optimal soil fertility, rotational grazing, and periodic mowing can help keep grass pastures in good condition and more competitive with weeds. Where broadleaf weeds become troublesome, however, **2,4-D, Banvel, Clarity, Curtail** (2,4-D + clopyralid), **Grazon P + D, ForeFront R + P, Milestone, Remedy Ultra, Stinger,** or **Weedmaster/Brash** (dicamba + 2,4-D) may be used. **Glyphosate** also may be used as a spot treatment, and **Crossbow** (2,4-D + triclopyr) and **Cimarron Max** (2,4-D + dicamba + metsulfuron methyl) are labeled for control of broadleaf and woody plant species in grass pastures. **Spike 20P** (tebuthiuron) also may be used in grass pastures for control of brush and woody plants (see Tables 5 and 6 for additional information).

Proper identification of target weed species is important. As shown in Table 5, weeds vary in their susceptibility to herbicides. Timing of herbicide appli-

cation also may affect the degree of weed control. Annuals and biennials are most easily controlled while young and relatively small. A fall or early-spring herbicide application works best if biennials or winter annuals are the main weed problem. Summer annuals are most easily controlled in the spring or early summer. Apply translocated herbicides to control established perennials when the weeds are in the bud-to-bloom stage. Perennials are most susceptible at this reproductive stage because translocated herbicides can move downward with food reserves to the roots, thus killing the entire plant.

For control of woody brush, apply **2,4-D, Banvel** or **Clarity, Crossbow,** or **Remedy Ultra** when the plants are fully leafed and actively growing. Where regrowth occurs, a second treatment may be needed in the fall. During the dormant season, oil-soluble formulations of **2,4-D** or **Crossbow** may be applied in fuel oil to the trunk. **Spike** controls many woody perennials and should be applied to the soil in the spring. **Spike** requires rainfall to move it into the root zone of target species. **Cimarron** may also be used in broadcast or basal soil applications for control of multiflora rose and other broadleaf weed species.

The weed-control options in grass pastures are shown in Table 6. Refer to Table 7 for information concerning grazing restrictions for herbicides used in grass pastures. Be cautious with any pesticide, and always consult the herbicide label for specific information about the use of a given product.

Forage Legumes

Weed control is important in managing forage legumes. Weeds can reduce the vigor of legume stands, reducing yield and forage quality. Good management begins with weed control that prevents weeds from becoming serious problems.

Establishment

To minimize problems, prepare the seedbed properly so that it is firm and weed free. Select an appropriate legume variety. If you use high-quality seed and follow the recommendations for liming and fertility, the legume crop may compete well with many weeds and reduce the need for herbicides.

In fields where companion crops such as oats are used to reduce weed competition, seed the small grain at half the rate for grain production to ensure that the legumes become established with minimum stress. If the legume is seeded without a companion crop (direct-seeded), the use of an appropriate herbicide is suggested.

Preplant-Incorporated Herbicides

Balan (benefin), **Eptam** (EPTC), and **Treflan** (trifluralin) are registered for preplant incorporation for legumes that are not seeded with grass or small-grain companion crops. These herbicides control most annual grasses and some broadleaf weeds. In fall plantings, the weeds controlled include winter annuals such as downy brome and cheat. In spring plantings of legumes, the summer annual weeds controlled include foxtails, pigweeds, lambsquarters, crabgrass, and fall panicum. **Eptam** can help suppress johnsongrass, quackgrass, yellow nutsedge, and shattercane, in addition to controlling many annual grasses and some broadleaf weeds. These herbicides do not effectively control mustards, smartweed, or established perennials.

Balan, Eptam, and **Treflan** *must* be thoroughly incorporated soon after application to avoid herbicide loss. They should be applied shortly before the legume is seeded to remain effective as long as possible into the growing season.

Weeds that emerge during crop establishment should be evaluated for their potential as problems. If they do not reduce the nutritional value of the forage or if they can be controlled by mowing, they should not be the primary focus of a postemergence herbicide application. For example, winter annual weeds do not compete vigorously with the crop after the first cutting in the spring. Unless they are unusually dense or production of weed seed becomes a concern, these weeds may not be a significant problem. Some weeds such as dandelions are palatable and may not require control if the overall legume stand is dense and healthy, but undesirable weeds must be controlled early to prevent their establishment.

Postemergence Herbicides

Poast Plus (sethoxydim) or **Select Max** (clethodim) may be applied to seedling alfalfa for control of annual and some perennial grass weeds after weed emergence. Grasses are more easily controlled when small. **Butyrac** (2,4-DB) controls many broadleaf weeds and may be applied postemergence in many seedling forage legumes. **Pursuit** (imazethapyr) or **Raptor** (imazamox) may be applied postemergence to seedling alfalfa for control of several broadleaf and grass weed species. **Buctril** (bromoxynil) may be used to control broadleaf weeds in seedling alfalfa. Be sure to apply Buctril while weeds are small, and use precautions to avoid an adverse effect on the crop. (See Table 8 for specific weed-control ratings and Table 9 for rates and remarks.)

Established Legumes

The best weed-control practice in established forage legumes is maintenance of a dense, healthy stand with proper management techniques. Chemical weed control in established forage legumes is often limited to late-fall or early-spring applications of herbicide. **Sencor** (metribuzin), **Sinbar** (terbacil), and **Velpar** (hexazinone) are applied after the last cutting in the fall or in the early spring. These herbicides control many broadleaf weeds and some grasses, too. The herbicide **2,4-DB** controls many broadleaf weeds in established alfalfa; it should be applied when the weeds are small and actively growing. **Pursuit** or **Raptor** may be applied postemergence to established alfalfa stands to control certain broadleaf and grass weed species. Refer to Tables 8 and 9 for additional remarks and weed-control suggestions.

Once grass weeds have emerged, they are particularly difficult to control in established alfalfa. **Poast Plus, Select,** or **Select Max** may be used in established alfalfa for postemergence control of annual and some perennial grasses. Optimal grass control is achieved if applications are made when grasses are small and before the weeds are mowed.

Table 9 outlines current suggestions for weed-control options in legume forages. The degree of control often varies with weed size, application rate, and environmental conditions. Select the correct herbicide for the specific weeds to be controlled (Table 8). Refer to Table 10 for grazing and harvesting restrictions for forage legumes. Always consult the herbicide label for specific information about using a given product.

Recommended Web Resources

http://www.cdms.net
This is an excellent index of chemical companies involved in agriculture that is searchable by product (trade name). It contains links to the companies' Web sites and is a good resource for obtaining current product label recommendations.

http://www.greenbook.net
This Web site contains extensive information on pesticides, including current pesticide labels and material safety data sheets.

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Table 1. Herbicides, formulations, and special statements

Trade name	Common name	Formulation	Restricted use	Groundwater advisory	Signal word
2,4-D amine	2,4-D amine	3.8 lb a.e./gal.[a]	—	Yes	**Danger**[b]
2,4-D ester	2,4-D ester	3.8 lb a.e./gal.[a]	—	—	Caution
Aim	carfentrazone-ethyl	1.9 lb/gal.	—	—	Caution
Balan	benefin	60%	—	—	Warning
Banvel	dicamba	4 lb a.e./gal.[a]	—	Yes	Warning
Buctril	bromoxynil	2 lb/gal.	—	—	Warning
Butyrac 200 or	2,4-DB	2 lb a.e./gal.[a]	—	Yes	**Danger**[b]
Butoxone 200		60%	—	—	Caution
Cimarron	metsulfuron	75%	—	—	**Danger**[b]
Cimarron Max	metsulfuron + dicamba + 2,4-D	12.25% + 35.25%	—	Yes	Caution
Clarity	dicamba	4 lb a.e./gal.[a]	—	Yes	Caution
Crossbow	2,4-D + triclopyr	2 + 1 lb a.e./gal.[a]	—	Yes	**Danger**[b]
Curtail	2,4-D + clopyralid	2 + 0.38 lb a.e./gal.[a]	—	—	Caution
Eptam	EPTC	7 lb/gal., 20%	—	Yes	**Danger**[b]
ForeFront R + P	aminopyralid + 2,4-D	0.33 + 2.67 lb a.e./gal.[a]	Yes	—	**Danger**[b]
Gramoxone Inteon	paraquat	2.0 lb/gal.	Yes	Yes	**Danger**[b]
Grazon P+D	picloram + 2,4-D	0.54 + 2 lb a.e./gal.[a]	—	—	Caution
Harmony Extra XP	thifensulfuron + tribenuron	75%	—	—	Caution
Harmony GT XP	thifensulfuron	75%	—	—	Caution
Harmony SG	thifensulfuron	50%	—	—	Caution
Harmony Extra SG	thifensulfuron + tribenuron	50%	—	—	Caution
Many	glyphosate	several	—	—	Warning
MCPA	MCPA	several	—	—	Caution
Milestone	aminopyralid	2 lb a.e./gal.[a]	—	—	Caution
Olympus	propoxycarbazone	70%	—	—	Caution
Osprey	mesosulfuron	4.5%	—	—	Caution
Poast Plus	sethoxydim	1 lb/gal.	—	—	Caution
Prowl H_2O	pendimethalin	38.7%	—	—	Caution
Pursuit	imazethapyr	2 lb/gal., 70%	—	—	Warning
Raptor	imazamox	1 lb/gal.	—	—	Caution
Remedy Ultra	tryclopyr	4.0 lb/gal.	—	—	Caution
Select Max	clethodim	0.97 lb/gal.	—	—	Warning
Sencor	metribuzin	75%	—	Yes	Caution
Sinbar	terbacil	80%	—	—	Caution
Spike	tebuthiuron	20%	—	Yes	Caution
Starane	fluroxypyr	1.5 lb/gal	—	—	Warning
Stinger	clopyralid	3 lb a.e./gal.[a]	—	Yes	Caution
Treflan	trifluralin	4 lb/gal., 10G	—	—	Caution
Velpar DF	hexazinone	75%	—	Yes	**Danger**[b]
Velpar L	hexazinone	2 lb/gal.	—	Yes	**Danger**[b]
Weedmaster/Brash	dicamba + 2,4-D	1 + 2.87 lb/gal.	—	Yes	**Danger**[b]

[a]a.e. = acid equivalent for these herbicides. All others are active ingredient (a.i.) formulations.
[b]**Danger:** Check label for safety equipment and precautions.

Table 2. Effectiveness of herbicides on weeds in small grains

This table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rate and weed size or growth stage. Performance may vary due to weather and soil conditions or other variables.

	Susceptibility to herbicide										
					Harmony						
Weed	2,4-D	Aim	Banvel or Clarity	Buctril	Extra XP / Extra SP	GT XP / SP	MCPA	Olympus	Osprey	Starane	Stinger
Winter annual											
Buckwheat, wild	5	5	**9**	**9**	**8**	**8**	6	5	N	**8**	**8**
Chickweed, common	5	N	7	6	**9**	6	5	–	–	**8**	N
Henbit	5	5	7	**8**	**9**	7	7	7	7	2	N
Horseweed (marestail)	**8**	N	**8**	7	**8**	5	**8**	–	–	**8**	**8**
Lettuce, prickly	**9**	5	**8**	6	**8**	7	**8**	N	N	**9**	**8**
Mustard spp., annual	**9**	**8**	7	**8**	**9**	**9**	**8**	**8**	N	5	N
Pennycress, field	**9**	**9**	7	**8**	**9**	**9**	**8**	**9**	N	**8**	N
Shepherd's purse	**9**	7	**8**	**9**	**9**	**9**	**8**	**9**	7	5	N
Summer annual											
Lambsquarters	**9**	**8**	**9**	**9**	**9**	**9**	**9**	N	N	2	N
Pigweed spp.	**9**	**8**	**9**	7	**9**	**9**	**8**	7	7	2	N
Ragweed, common	**9**	6	**9**	**9**	**8**	5	**9**	–	–	**9**	**8**
Ragweed, giant	**9**	4	**9**	**8**	5	5	**9**	–	–	**8**	**8**
Smartweed, Pennsylvania	7	5	**9**	**8**	**9**	**9**	7	N	N	4	7
Perennial											
Dandelion	**9**	N	**8**	6	6	5	**8**	–	–	4	**9**
Garlic, wild											
Aerial bulblets	6*	N	5	N	**9**	**9**	5	–	–	N	N
Bulbs	N	N	N	N	5	5	N	–	–	N	N
Thistle, Canada	7	N	7	5	6	4	6	–	–	2	**9**

9 = excellent, **8** = good, 7 = fair, 6 = poor, 5 or 4 = unsatisfactory, N = no control or not labeled, – = unknown. Boldface indicates acceptable control.

*2,4-D ester at maximum use rate.

Table 3. Weed control in small grains

Herbicide	Broadcast rate/acre	Remarks (See Table 4 for grazing restrictions.)
Oats and wheat with legume underseeding		
2,4-D amine, 3.8 lb a.e.	½ to 1½ pt	Winter wheat is more tolerant than oats. Apply in spring after full-tiller but before joint stage. *Do not treat in the fall.* Use lower rate if underseeded with legume. Some legume damage may occur. May be used as preharvest treatment at 1 to 2 pt per acre during hard-dough stage.
Buctril 2E	1 to 1½ pt	Apply Buctril alone to fall-seeded small grains in the fall or spring before the boot stage. Weeds are best controlled before the 3- to 4-leaf stage. Buctril 2E may be applied at 1 to 1½ pt per acre to small grains underseeded with alfalfa.
MCPA amine	¼ to 1½ pt	Less likely than 2,4-D to damage oats and legume underseeding. Apply from 4-leaf stage to early boot stage. Rate varies with crop and weed size and presence of legume underseeding.
Oats and wheat without legume underseeding		
Aim EW	0.5 to 2.0 oz	*Do not use with legume underseeding.* Apply to winter wheat, barley, and oats from 30 days before planting up to the jointing stage of growth. Make applications to actively growing weeds up to 4 in. tall and rosettes less than 3 in. across. Larger and harder-to-control weeds require higher rates and tank-mix combinations.
Banvel or Clarity, 4 lb a.e.	2 to 4 fl oz	*Do not use with legume underseeding.* In fall-seeded wheat, apply before jointing stage. In spring-seeded oats, apply before oats exceed 5-leaf stage. Clarity may be used as a preharvest treatment when wheat is in the hard-dough stage and the green color is gone from the nodes of the stem. It is not recommended that wheat being grown for seed be treated with Clarity because a reduction in germination or vigor may occur.
Harmony Extra XP or Harmony GT XP	0.3 to 0.6 oz	*Do not use with legume underseeding.* Harmony Extra XP, Harmony GT XP, Harmony SP, and Harmony Extra SP have similar labels. Make applications to wheat after the crop is in the 2-leaf stage but before the flag leaf is visible. For spring oats, make applications after the crop is in the 3-leaf stage but before jointing.
Harmony SP or Harmony Extra SP	0.45 to 0.90 oz	The use rate for spring oats is 0.3 to 0.4 oz per acre. Do not use on "Ogle," "Porter," or "Premier" oat varieties, as crop injury may result. Wild garlic should be less than 12 in. tall, with 2 to 4 in. of new growth. For wild garlic control in the fall apply 0.5 oz in the fall followed by 0.5 oz in the spring. If making a single application for wild garlic control, apply 0.6 oz in the spring. Annual broadleaf weeds should be past the cotyledon stage, actively growing, and less than 4 in. tall or across. Nonionic surfactant at 0.25% volume per volume (v/v) should be included in the spray mixture. When liquid fertilizer is used as the carrier, use 1/16 to ¼% v/v surfactant. *Temporary stunting and yellowing may occur when Harmony Extra XP is applied using liquid fertilizer solution as the carrier.* These symptoms are intensified with the addition of surfactant. Without the addition of surfactant, wild garlic control may be erratic. Do not plant any crop other than wheat or oats within 45 days after application.
Starane, 1.5 lb a.e.	½ to ⅔ pt	*Do not use with legume underseeding.* Apply broadcast postemergence to actively growing wheat, barley, or oats from the 2-leaf stage up to and including flag leaf emergence for control of certain broadleaf weeds. Apply when weeds are actively growing, but before 8 inches tall. Only weeds emerged at the time of application will be controlled. Extreme growing conditions such as drought or near-freezing temperatures prior to, at, or following time of application may reduce weed control and increase crop injury at all stages of growth.

Table 3. Weed control in small grains (cont.)

Herbicide	Broadcast rate/acre	Remarks (See Table 4 for grazing restrictions.)
Oats and wheat without legume underseeding (cont.)		
Stinger, 3 lb a.e.	¼ to ⅓ pt	*Do not use with legume underseeding.* Apply to small grains from the 3-leaf stage up to the early boot stage. For control of Canada thistle, ⅓ pt per acre should be used. For control of additional weeds, other postemergence herbicides registered for use in wheat may be tank-mixed with Stinger.
Wheat only		
2,4-D ester, 3.8 lb a.e.	½ to 1 pt	*Do not use with legume underseeding.* Apply in the spring after full-tiller but before joint stage. For *preharvest treatment,* apply 1 to 2 pt per acre during hard-dough stage. For control of wild garlic or wild onion, apply 1 to 2 pt in the spring when wheat is 4 to 8 in. tall, after tillering but before jointing. *These rates may injure the crop and only suppress wild garlic.*
glyphosate 3 lb a.e./gal.	1 to 2 pt	*Do not use with legume underseeding.* Apply as a *preharvest treatment only* after the hard-dough stage of grain (30% or less moisture) and at least 7 days before harvest. Application rates will depend on the glyphosate formulation used (see respective labels). It is not recommended that wheat being grown for seed be treated with glyphosate because a reduction in germination or vigor may occur.
Olympus	0.6 to 0.9 oz	*Do not use with legume underseeding.* Controls cheatgrass and certain broadleaf weeds. Apply to small, actively growing weeds after wheat emergence but before the jointing stage of growth. Applications before wheat tiller initiation have a greater risk of stunting the crop. Cheat and Japanese brome are more susceptible than downy brome and generally are controlled adequately in both fall and spring with the 0.6 oz rate. Fall applications at 0.9 oz are recommended for downy brome control. Apply with a nonionic surfactant at 0.25% to 0.5% v/v. Liquid nitrogen fertilizer can be used as a spray carrier. Fall applications in liquid fertilizer solutions should not exceed 50% liquid nitrogen and no more than 30 pounds of actual nitrogen per acre. Only add 0.25% v/v surfactant when applied with fertilizer carrier. STS soybeans can be planted 4 months after Olympus treatment. Grain sorghum, sunflowers, and non-STS soybean can be planted 12 months after Olympus treatment if cumulative precipitation exceeds 24 inches. Corn can be planted 18 months after Olympus application if cumulative precipitation exceeds 30 inches. Risk of Olympus carryover is greatest on high-pH soils.
Osprey	4.75 oz	*Do not use with legume underseeding.* Controls Italian (annual) ryegrass. Apply to actively growing weeds after wheat emergence but before the jointing stage of growth. Applications before wheat tiller initiation have a greater risk of stunting the crop. Must be applied with MSO or nonionic surfactant plus nitrogen fertilizer adjuvants. Topdress liquid nitrogen fertilizer applications are not recommended within 21 days of Osprey treatment because of the increased potential for crop injury. Do not plant barley, sunflowers, or soybean until 90 days; corn until 12 months; or any other crop until 10 months after Osprey application.
Paramount	5.3 oz	*Do not use with legume underseeding.* Apply *prior to wheat emergence only.* Plant wheat at least 1 inch deep; shallow planting (<1 inch deep) may result in possible crop injury. Do not apply more than 16 oz per acre per year. Do not plant crops other than wheat or sorghum for at least 10 months after application. Do not allow livestock to graze treated areas. Do not feed treated forage, hay, silage, straw, or seed to livestock.

Table 3. Weed control in small grains (cont.)

Herbicide	Broadcast rate/acre	Remarks (See Table 4 for grazing restrictions.)
Wheat only (cont.)		
Prowl H_2O	1.5 to 3.0 pt	*Do not use with legume underseeding.* Apply postemergence only from the first-leaf stage until before the flag leaf is visible/emerged. Plant wheat at least 0.5 in. to 1.0 in. deep to avoid crop injury. Prowl H_2O should be applied prior to weed emergence. Prowl H_2O will not control emerged weeds. Do not apply more than 3.0 pt per season. If loss of stand occurs, any crop registered for Prowl H_2O preplant-incorporated use may be replanted the same year without adverse effects. Do not replant wheat. Do not apply Prowl H_2O within 60 days of harvest of wheat grain or straw. Do not apply Prowl H_2O within 28 days of harvest of wheat hay or within 11 days of harvest of wheat forage.

Table 4. Grazing restrictions for small-grain herbicides

Herbicide name				Days after treatment before use			
				Graze green			
Trade	Common	Crops	Applied	Beef	Dairy	Feed straw	Withdraw for meat
Aim	carfentrazone-ethyl	wheat, oats, barley	Prejoint	7	7	7	7
Banvel or Clarity	dicamba	wheat, oats, barley	Prejoint	0	7	37	30
Buctril	bromoxynil	wheat, oats, rye, barley	Preboot	45	45	45	45
Harmony Extra XP	thifensulfuron + tribenuron	wheat, barley, spring oats	Prejoint	No	No	Yes	0
Harmony GT XP	thifensulfuron	wheat, barley, spring oats	Prejoint	No	No	Yes	0
Many	2,4-D	wheat, oats, rye, barley	Prejoint	14	14	0	14
Many	2,4-D, late	wheat, oats, rye, barley	Before harvest	No	No	No	...*
Many	glyphosate	wheat	Before harvest	14	14	14	...*
Many	MCPA	wheat, oats, rye, barley	Prejoint	7	7	0	7
Olympus	propoxycarba-zone	wheat	Prejoint	0	0	71	...*
Osprey	mesosulfuron	wheat	Prejoint	30	30	60	...*
Paramount	quinclorac	wheat	Preemergence	No	No	No	...*
Starane	fluroxypyr	wheat, oats, barley	2 leaf through flag leaf	7	7	40	...*
Stinger	clopyralid	wheat, oats, barley	Preboot	7	7	No	7

*No withdrawal information available.

Table 5. Effectiveness of herbicides on weeds in grass pastures

This table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rate and weed size or growth stage. Performance may vary due to weather and soil conditions or other variables.

	Susceptibility to herbicide										
Weed	2,4-D	Banvel or Clarity	Cimarron	Cimarron Max	Crossbow	Curtail	ForeFront R + P	glyphosate[a]	Grazon P+D	Milestone	Stinger
Winter annual											
Horseweed (marestail)	**8**	**9**	**9**	**9**	**9**	**8**	**9**	**9**	**8**	**9**	**8**
Pennycress, field	**9**	**8**	**8**	**8**	**9**	**8**	N	**9**	**9**	N	N
Summer annual											
Ragweed, common	**9**	**9**	5	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**
Ragweed, giant	**9**	**9**	5	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**
Biennial											
Burdock, common	**9**	**9**	7	**9**	**9**	**8**	**9**	**8**	**9**	**9**	**8**
Hemlock, poison	**8**	**8**	5	5	**8**	7	**8**	**8**	**8**	6	N
Thistle, bull	**9**	**9**	**8**	**8**	**9**	**9**	**9**	**9**	**9**	**9**	**9**
Thistle, musk	**8**	**9**	**8**	**8**	**9**	**8**	**9**	**9**	**9**	**9**	**9**
Perennial[b]											
Daisy, oxeye	7	**8**	**9**	**9**	**8**	**8**	**8**	**8**	**8**	**8**	**8**
Dandelion	**9**	**8**	**8**	**8**	**9**	**8**	**8**	7	**9**	6	**8**
Dock, curly	7	**9**	**9**	**9**	**9**	7	**9**	**8**	**8**	**9**	7
Goldenrod spp.	**8**	**8**	5	5	**8**	7	**8**	**9**	**8**	6	5
Hemlock, spotted water	**8**	**9**	N	7	**9**	7	**8**	**8**	N	**8**	5
Ironweed	7	**8**	5	5	**8**	7	**9**	**9**	**8**	**9**	5
Milkweed, common	6	7	5	5	7	5	N	7	N	N	5
Nettle, stinging	**8**	**8**	N	5	**8**	7	N	**8**	**9**	N	5
Plantain spp.	**9**	**8**	**8**	**8**	**9**	7	N	**8**	**9**	N	N
Rose, multiflora[c]	7	**8**	**9**	**9**	**9**	7	7	**8**	**8**	N	5
Snakeroot, white	7	**9**	N	**8**	**8**	7	N	**8**	**8**	N	7
Sorrel, red	5	**9**	**9**	**9**	**9**	7	**8**	**8**	**8**	**8**	7
Sowthistle, perennial	7	**9**	**8**	**8**	**9**	7	**8**	**8**	**8**	**8**	7
Thistle, Canada	7	**8**	**8**	**8**	**8**	**9**	**9**	**8**	**9**	**9**	**9**

9 = excellent, **8** = good, 7 = fair, 6 = poor, 5 = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.

[a]Spot treatment only.

[b]Perennial weeds may require more than one application.

[c]Spike also is an effective herbicide for multiflora rose control (weed susceptibility = **9**).

Table 6. Broadleaf weed control in grass pastures

Herbicide	Rate/acre	Remarks (See Table 7 for grazing restrictions.)
2,4-D, 3.8 lb a.e. (amine or low-volatile ester)	2 to 4 pt	Broadleaf weeds should be actively growing. Higher rates may be needed for less susceptible weeds and some perennials. Spray bull or musk thistles in the rosette stage (spring or fall) while they are actively growing. Spray perennials such as Canada thistle in the bud stage or the fall regrowth stage. Spray susceptible woody species in the spring when leaves are fully expanded. *Do not apply to newly seeded areas or to grass when it is in boot-to-milk stage.* Be cautious of spray drift.
Banvel or Clarity, 4 lb a.e.	Annuals: ½ to 1½ pt Biennials: ½ to 3 pt Perennials: 2 to 4 pt	Use lower rates for susceptible annuals when they are small and actively growing and for susceptible biennials in the early rosette stage. Use higher rates for larger weeds, for less susceptible weeds, for established perennials in dense stands, and for certain woody brush species. Be cautious of spray drift.
Cimarron 60DF or Cimarron Max	0.1 to 1 oz Part A: 0.25 to 1 oz Part B: 1 to 4 oz	Apply in the spring or early summer when weeds are less than 4 in. tall and are actively growing. Include a nonionic surfactant of at least 80% active ingredient at 1 to 2 qt per 100 gal. spray solution (¼ to ½% v/v). Bluegrass, bromegrass, orchardgrass, timothy, and native grasses such as bluestem and grama have demonstrated good tolerance. Bluegrass, bromegrass, and orchardgrass should be established for at least 6 months; timothy for 12 months; and fescue for 24 months at the time of application, or injury may result. *Application to fescue may result in stunting and seed head suppression.* For control of multiflora rose with broadcast applications, apply Cimarron/Cimarron Max at ½ oz per acre when multiflora rose is less than 3 ft tall. Applications should be made in the spring, soon after multiflora rose is fully leafed. Cimarron/Cimarron Max can also be used as a spot and basal soil treatment for weed control. Consult the product label for species details regarding these types of applications.
Crossbow	Annuals: 1 to 2 qt Biennials and herbaceous perennials: 2 to 4 qt Woody perennials: 6 qt	Apply to foliage during warm weather when brush and broadleaf weeds are actively growing. When applying as a spot spray, thoroughly wet all foliage. See herbicide label for more specific rate recommendations. Be cautious of spray drift. Best control of multiflora rose occurs when application is made during early- to mid-flowering stage.
Curtail 2.38S	2 to 4 qt/acre	Apply when weeds are young and actively growing. Grasses are tolerant, but new grass seedlings may be injured. For Canada thistle, apply to thistle at least 4 in. tall but before thistle reaches bud stage. *Do not spray pastures containing desirable forbs, such as alfalfa or clover, unless injury can be tolerated.* Do not use hay or straw from treated areas for composting or mulching on susceptible broadleaf crops. Refer to product label for additional precautions.
ForeFront	1.5 to 2.6 pt	Apply when weeds are young and actively growing. Use appropriate rate for weed species and growth stage. Follow all precautions on label. There are no grazing restrictions for any livestock. *Do not use ForeFront if loss of legume or other broadleaf species cannot be tolerated.*

Table 6. Broadleaf weed control in grass pastures (cont.)

Herbicide	Rate/acre	Remarks (See Table 7 for grazing restrictions.)
glyphosate	1 to 2% solution (spot treatment)	Controls a variety of herbaceous and woody brush species, such as multiflora rose, brambles, poison ivy, and quackgrass. Spray foliage of target vegetation completely and uniformly but not to point of runoff. Avoid contact with desirable nontarget vegetation. Consult label for recommended timing of application for maximum effectiveness on target species. *No more than 1/10 of any acre should be treated at one time.* Further applications may be made in the same area at 30-day intervals. Use only where livestock movement can be controlled to prevent grazing for 14 days. Treated areas may be reseeded after 14 days.
Grazon P+D	2 to 4 pt	Apply when weeds are young and actively growing. Use appropriate rate for weed species and growth stage. Applications to perennial grasses should be made only after grasses are well established. *Do not apply Grazon within the area occupied by roots of desirable trees unless injury can be tolerated.* Grazon may injure or kill legume species. Follow all precautions on label.
Milestone 2L	3 to 7 fl oz	Apply when weeds are young and actively growing. Use appropriate rate for weed species and growth stage. Follow all precautions on label. There are no grazing restrictions for any livestock. *Do not use Milestone if loss of legume or other broadleaf species cannot be tolerated.*
Remedy Ultra	1 to 2 qt	Apply when weeds or brush is actively growing. Use appropriate rate for the weed/brush species and growth stage. Follow all precautions on label. Do not use Remedy Ultra if loss of legume species cannot be tolerated.
Spike 20P	10 to 20 lb	For control of brush and woody plants in rangeland and grass pastures. Requires sufficient rainfall to move herbicide into root zone. May kill or injure desirable legumes and grasses where contact is made. Injury is minimized by applying when grasses are dormant. Do not apply on or near field crops or other desirable vegetation. *Do not apply where soil movement is likely.* Refer to product label for additional restrictions.
Stinger 3S	2/3 to 1 1/3 pt	Apply when weeds are young and actively growing. Grasses are tolerant, but new grass seedlings may be injured. For Canada thistle, apply to thistle at least 4 in. tall but before thistle reaches bud stage. *Do not spray pastures containing desirable forbs, such as alfalfa or clover, unless injury can be tolerated.* Do not use hay or straw from treated areas for composting or mulching on susceptible broadleaf crops. Refer to product label for additional precautions.

Table 7. Restrictions on herbicides used in permanent grass pastures

Herbicide name		Days after treatment before use				
		Dairy		Beef		Slaughter
Trade	Common	Graze	Hay	Graze	Hay	
Banvel or Clarity	dicamba 1 pt	7	37	0	0	30
	2 pt	21	51	0	0	30
	4 pt	40	70	0	0	30
Cimarron	metsulfuron	0	0	0	0	0
Cimarron Max	metsulfuron + dicamba + 2,4-D	7	37	0	0	30
Crossbow	triclopyr + 2,4-D	14	NGS[a]	0	0	3
Curtail	2,4-D + clopyralid	14	30	0	30	7
ForeFront	aminopyralid + 2,4-D	0	7	0	7	0
Grazon P+D	picloram + 2,4-D	7	30	0	30	3
Many	2,4-D	7 to 14[b]	30	0	30	3 to 7[b]
Many	glyphosate					
Spot treat		14	14	14	14	0
Renovation		56	56	56	56	0
Milestone	aminopyralid	0	0	0	0	0
Stinger[c]	clopyralid	0	0	0	0	0
Spike 20P	tebuthiuron					
< 20 lb/acre		0	365	0	365	0
> 20 lb/acre		..... *Do not use for livestock for 1 year*.....				

[a]NGS = next growing season.
[b]Labels vary (withdrawal unnecessary if more than 14 days after treatment).
[c]Do not transfer livestock onto a broadleaf crop area within 7 days of grazing treated area.

Table 8. Effectiveness of herbicides on weeds in legume and legume–grass forages

This table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rate and weed size or growth stage. Performance may vary due to weather and soil conditions or other variables.

Weed	Balan	Buctril	Butyrac	Eptam	glyphosate[a, b]	Gramoxone Inteon	Poast Plus	Pursuit	Raptor	Select or Select Max	Sencor[a]	Sinbar	Treflan	Velpar
Winter annual														
Brome, downy	9	N	N	7	9	8	8	6	7	9	8	8	9	9
Chickweed, common	8	6	6	7	9	9	N	8	8	N	9	9	5	9
Henbit	5	8	6	8	7	9	N	7	7	N	9	9	8	8
Mustard, wild	5	8	8	6	9	8	N	9	9	N	9	9	5	9
Pennycress, field	5	9	8	6	9	7	N	9	9	N	9	9	5	9
Shepherd's purse	5	9	8	7	9	8	N	8	9	N	9	9	5	9
Yellow rocket	5	7	7	6	9	7	N	8	8	N	9	9	5	9
Summer annual														
Barnyardgrass	9	N	N	9	9	8	9	7	8	9	7	7	9	7
Crabgrass spp.	9	N	N	9	9	6	9	7	7	9	7	8	8	7
Foxtail spp.	9	N	N	9	9	9	9	8	8	9	6	8	9	7
Lambsquarters, common	9	9	8	8	9	8	N	6	8	N	9	9	8	9
Nightshade spp.[c]	N	9	7	8	8	8	N	9	9	N	5	8	5	7
Panicum, fall	9	N	N	9	9	8	9	7	8	9	6	8	9	6
Pigweed spp.	9	7	8	9	9	8	N	9	9	N	9	8	8	9
Ragweed, common	N	9	9	7	9	8	N	7	7	N	8	8	5	8
Smartweed, Pennsylvania	N	9	6	5	8	8	N	9	9	N	8	8	5	8
Perennial														
Canada thistle	N	5	5	N	8	N	N	6	6	N	N	N	N	N
Dandelion	N	N	7	N	8	N	N	6	6	N	7	6	N	8
Dock, curly	N	N	5	N	6	N	N	6	6	N	6	6	N	7
Nutsedge, yellow	N	N	N	8	7	N	N	6	6	N	N	N	N	N
Orchardgrass	5	N	N	6	8	5	6	N	N	7	5	5	5	7
Quackgrass	6	N	N	6	9	5	7	5	5	8	5	6	5	6

9 = excellent, **8** = good, 7 = fair, 6 = poor, 5 = unsatisfactory, N = no control or not labeled.
[a]Glyphosate and Sencor are labeled for use in mixed legume–grass forages. No other herbicides are cleared for this use.
[b]Spot treatment only.
[c]Control of different species may vary.

Table 9. Weed control in legume forages

Herbicide	Legume	Time of application	Broadcast rate/acre	Remarks (See Table 10 for haying restrictions.)
Seedling year				
Balan 60DF	Alfalfa, birdsfoot trefoil, red clover, ladino clover, alsike clover	Preplant incorporated	2 to 2½ lb	Apply shortly before seeding. Do not use with any companion crop of small grains.
Buctril 2E	Alfalfa only	Postemergence	1 to 1½ pt	Apply in the fall or spring to seedling alfalfa with at least 4 trifoliate leaves. Apply to weeds at or before the 4-leaf stage or 2 in. in height (whichever is first). May be tank-mixed with 2,4-DB for improved control of pigweed; however, crop burn may occur from this mixture, especially under warm, humid conditions. Eptam, previously used, may enhance Buctril burn to alfalfa. *Do not apply when temperatures are likely to exceed 70°F during or for 3 days following application* or when the crop is stressed. Do not add a surfactant or crop oil.
Butyrac 200 or Butoxone 200	Alfalfa, birdsfoot trefoil, ladino clover, red clover, alsike clover	Postemergence	1 to 3 qt (amine)	Use when weeds are less than 3 in. tall or less than 3 in. across if rosettes. Use higher rates for seedling smartweed or curly dock. May be tank-mixed with Poast Plus. *Do not use on sweet clover.*
Eptam 7E, 20G	Alfalfa, birdsfoot trefoil, lespedeza, clovers	Preplant incorporated	3½ to 4½ pt (7E) 15 lb (20G)	Apply shortly before seeding. Do not use with any companion crop of small grains.
Gramoxone Inteon	Alfalfa only	Between cuttings	1 pt	Apply within 5 days after cutting and before alfalfa regrowth is 2 in. Add surfactant according to label instructions. Do not apply more than twice during seedling year. *Gramoxone Inteon is a restricted use pesticide.*
Poast Plus	Alfalfa, birdsfoot trefoil	Postemergence	1⅛ to 2¼ pt	Best grass control is achieved when applications are made prior to mowing. If tank-mixed with 2,4-DB, follow 2,4-DB harvest and grazing restrictions and add no additives with this tank mix. Do not apply more than a total of 9.75 pt of Poast Plus per acre in one season.

Table 9. Weed control in legume forages (cont.)

Herbicide	Legume	Time of application	Broadcast rate/acre	Remarks (See Table 10 for haying restrictions.)
Seedling year (cont.)				
Pursuit 2AS or 70DG	Alfalfa only	Postemergence	3 to 6 fl oz (2AS) 1.08 to 2.16 oz (70DG)	Apply when seedling alfalfa is in the second-trifoliate stage or larger and when the majority of weeds are 1 to 3 in. tall. For low-growing weeds, apply before the rosette exceeds 3 in. in diameter. Always include a nonionic surfactant or crop-oil concentrate and a liquid nitrogen fertilizer solution, and apply in 10 or more gallons of water per acre. When applied to seedling alfalfa, Pursuit may cause a temporary reduction in growth. Do not apply more than 6 fl oz or 2.16 oz per acre per year. *If applied under cool conditions (≤ 40°F), temporary stunting and yellowing of alfalfa may occur.*
Raptor 1AS	Alfalfa	Postemergence	4 to 6 fl oz	Apply Raptor when seedling alfalfa is in the second-trifoliate stage or larger and the majority of weeds are 1 to 3 in. tall. Applications require the addition of a crop-oil concentrate or nonionic surfactant and a nitrogen fertilizer solution. Apply Raptor in 10 or more gallons of water per acre. A maximum of 6 fl oz of Raptor per season may be applied to alfalfa. When Raptor is applied to seedling alfalfa, there may be a temporary reduction in growth.
Select 2EC, Select Max 1EC	Alfalfa	Postemergence	6 to 8 fl oz 9 to 16 fl oz	May be applied to seedling or established alfalfa grown for seed, hay, silage, green chop, or direct grazing. See label for tank-mix partners. If tank-mixed with 2,4-DB, follow 2,4-DB grazing and harvest restrictions. Do not plant rotational crops until 30 days after Select application.
Treflan HFP, TR-10	Alfalfa only	Preplant incorporated	1 to 1½ pt (HFP) 5 to 7½ lb (TR-10)	May be applied as a preplant-incorporated treatment for preemergence control of certain grass and small-seeded broadleaf species. Some crop stand reduction and stunting may occur.
Established stands				
Butyrac 200 or Butoxone 200	Alfalfa only	Growing	1 to 3 qt (amine)	Spray when weeds are less than 3 in. tall or less than 3 in. wide if rosettes. Fall treatment of fall-emerged weeds may be better than spring treatment. May be tank-mixed with Poast Plus.
glyphosate	Alfalfa Alfalfa, clover, and alfalfa or clover–grass mixtures	Postemergence Growing	1 to 2% solution (spot treatment)	No more than 1/10 of any acre should be treated at one time. Further applications may be made in the same area at 30-day intervals. Avoid contact with desirable, nontarget vegetation because damage may occur. Refer to label for recommended timing of application for maximum effectiveness on target species.

Table 9. Weed control in legume forages (cont.)

Herbicide	Legume	Time of application	Broadcast rate/acre	Remarks (See Table 10 for haying restrictions.)
Established stands (cont.)				
Gramoxone Inteon	Alfalfa only	Between cuttings	1.0 pt	Between cuttings, treatments should be applied immediately after hay removal, within 5 days after cutting, and with less than 2 in. of growth. Weeds germinating after treatment are not controlled. *Gramoxone Inteon is a restricted use pesticide.*
Gramoxone Inteon	Alfalfa, clover	Dormant	2.0 to 3.0 pt	For dormant season, apply after last fall cutting or before spring growth is 2 in. tall. Weeds should be succulent and growing at the time of application. Do not apply if fall regrowth is more than 6 in. *Gramoxone Inteon is a restricted use pesticide.*
Poast Plus 1E	Alfalfa	Postemergence	1⅛ to 3¾ pt	Best grass control is achieved when applications are made prior to mowing. If tank-mixed with 2,4-DB, follow 2,4-DB grazing and harvest restrictions. Do not apply more than a total of 9.75 pt of Poast Plus per acre in one season. Applications up to 3.75 pt per acre can be made for perennial grass control.
Pursuit 2AS or 70DG	Alfalfa only	Postemergence	3 to 6 fl oz (2AS) 1.08 to 2.16 oz (70DG)	Apply in the fall or spring to dormant or semi-dormant alfalfa (less than 3 in. of regrowth), or between cuttings. Do not apply more than 4 fl oz of the 2AS formulation or 1.44 oz of the 70DG formulation to alfalfa during the last year of the stand. Always include a nonionic surfactant or crop-oil concentrate and a liquid nitrogen fertilizer solution, and apply in 10 or more gallons of water per acre. *Applications made under cool conditions (≤ 40°F) may cause temporary stunting and yellowing of alfalfa.*
Raptor 1AS	Alfalfa	Postemergence	4 to 6 fl oz	Raptor can be applied to dormant or semi-dormant alfalfa in the fall, winter, or spring, or between cuttings. Any application should be made before significant alfalfa growth or regrowth (3 in.). Applications require the addition of a crop-oil concentrate or nonionic surfactant and a nitrogen fertilizer solution. Ap-ply Raptor in 10 or more gallons of water per acre. A maximum of 6 fl oz of Raptor per season may be applied to alfalfa.
glyphosate	Alfalfa	Last cutting	1 to 2 pt (3 lb a.e./gal.)	For use in declining alfalfa stands prior to crop rotation. Apply before last cutting in fall or spring for control of certain perennial grass and broadleaf weed species. *Do not use for alfalfa grown for seed.*

Table 9. Weed control in legume forages (cont.)

Herbicide	Legume	Time of application	Broadcast rate/acre	Remarks (See Table 10 for haying restrictions.)
Established stands (cont.)				
Select 2EC Select Max 1EC	Alfalfa	Postemergence	8 to 16 fl oz 12 to 16 fl oz	For control of annual grasses in established alfalfa, use a minimum of 8 fl oz per acre (Select) or 12 fl oz per acre (Select Max). See label for tank-mix partners. If tank-mixed with 2,4-DB, follow 2,4-DB grazing and harvest restrictions.
Sencor 75DF	Alfalfa and alfalfa–grass mixtures	Dormant	½ to 1⅓ lb	Apply once in the fall or spring before new growth starts. Rate is based on soil type and organic-matter content. Higher rates may injure grass component. Do not use on sandy soils or soils with pH greater than 7.5.
Sencor 75DF	Alfalfa	Postemergence	1 to 1⅓ lb	May be applied postdormant but prior to 3 in. of alfalfa top growth when impregnated on dry fertilizer.
Sinbar 80W	Alfalfa only	Dormant	½ to 1½ lb	Apply once in the fall or spring before new growth starts. Use lower rates for coarser soils. Do not use on sandy soils with less than 1% organic matter, as severe injury may result. Do not plant any crop for 2 years after application.
Treflan HFP TR-10	Alfalfa	Dormant or after a cutting during the growing season	4 pt (HFP) 20 lb (TR-10)	A single rainfall or overhead-sprinkler irrigation of 0.5 in. or more, flood irrigation, or furrow irrigation after application is required to activate the herbicide. If activation does not occur within 3 days after application, incorporate using equipment that provides thorough soil mixing with minimum damage to the established alfalfa. Treflan HFP may be surface-applied or applied by chemigation.
Velpar 2L 75DF	Alfalfa only	Dormant	1 to 3 qt ⅓ to 2 lb	Apply in the fall or spring before new growth exceeds 2 in. in height. May also be applied to stubble after hay crop removal but before regrowth exceeds 2 in. Do not plant any crop except corn or root crops within 2 years of treatment. Corn may be planted 12 months after treatment, provided that the use rate did not exceed 3 pt per acre, except in areas of low rainfall (20 in. or less).

Table 10. Herbicides used in forage legumes and restrictions

Herbicide name		Applied on/at		Days before use	
Trade	Common	Forage[a]	When[a]	Graze	Hay
Seedling legumes					
Balan	benefin	AL, CL, BT	PPI	0	0
Buctril	bromoxynil	AL	Postfall	60	60
		AL	Postspring	30	30
Butyrac 200 or Butoxone 200	2,4-DB	AL, CL, BT AL only	Post	60	60
Eptam	EPTC	AL, CL, BT	PPI	...[b]	...[b]
Gramoxone Inteon	paraquat	AL	After cut[c]	60	60
Poast Plus	sethoxydim	AL	Post	7	14
		CL	Post	20	20
Pursuit	imazethapyr	AL	Post	30	30
Raptor	imazamox	AL	Post	20	20
Select	clethodim	AL, BT	Post	15	15
Treflan	trifluralin	AL	PPI	21	21
Established legumes					
Gramoxone Inteon	paraquat	AL	Post	60	60
Gramoxone Inteon	paraquat	AL, CL	Dormant	42	42
Many	2,4-D	AL	Post	30	30
Many	glyphosate	AL	Post	14	14
Many	glyphosate	AL	Spot treat	56	56
Many	glyphosate	AL, CL, BT	Renovate	7	7
Poast Plus	sethoxydim	AL, CL, BT	Last cutting	7	14
Pursuit	imazethapyr	AL	After cut[c]	30	30
Raptor	imazamox	AL	Post	20	20
Select	clethodim	AL, BT	Post	15	15
Select Max	clethodim	AL, BT	Post	15	15
Sencor	metribuzin	AL	Dormant	28	28
Sencor	metribuzin	AL	Predormant/ postdormant[d]	60	60
Sinbar	terbacil	AL	Dormant	...[b]	...[b]
Treflan	trifluralin	AL	Dormant or after cutting	21	21
Velpar	hexazinone	AL	Dormant	30	30

[a]AL = alfalfa, CL = clover (red, alsike, or ladino), BT = birdsfoot trefoil, PPI = preplant incorporated.
[b]No grazing information on label.
[c]Between cuttings (fewer than 5 days after cut, with less than 2 in. regrowth).
[d]If impregnated on dry fertilizer.

4

Plant Disease Management for Field Crops

Yield and quality of field crops in Illinois are affected by disease each year. The damage from crop diseases can be minimized by implementing optimal management practices. Disease-management programs should use integrated disease-control measures that focus on the specific diseases known to occur in a particular area. Disease-management tactics include using resistant or tolerant crop varieties, crop rotations, fungicides, and appropriate agronomic practices. This chapter emphasizes information on fungicides, which in most cases should be used only in conjunction with other disease-control measures or after such measures have been implemented.

The success of disease-control measures may depend on how carefully crops are scouted and how accurately the disease is diagnosed. Periodic scouting increases the likelihood that disease controls will be applied properly and at the time when they are most effective, and it can help prevent economic loss from disease and unnecessary use of fungicides.

Additional information for the management of important diseases of corn, soybeans, wheat, and alfalfa can be found in Table 1 and in the following issues of *Report on Plant Disease (RPD):* no. 123, "Winter Wheat Disease Management Program"; no. 212, "Illinois Corn Disease Management Program"; no. 308, "Alfalfa Disease Management Program"; no. 507, "Illinois Soybean Disease Management Program"; and no. 1002, "Characteristics of Fungicides Used in Field Crops." These and other issues of *RPD* on specific diseases are available on the Web at http://www.ag.uiuc.edu/~vista/pubs.html.

Disease Diagnosis

Accurate diagnosis of a disease is a critical initial step for successful disease management. Several different diseases or other plant health problems cause similar symptoms on plants, and an accurate diagnosis is required to choose the best disease-control measures. Many fungicides have specific activity against only certain types of plant pathogens, and their incorrect use wastes time and money. Diligent effort should be made to ensure that diseases are diagnosed accurately. Plants should be collected for diagnosis as soon as disease symptoms are noted. It can be very difficult to accurately diagnose a disease after the plants are dead and dry. The University of Illinois can help with disease diagnosis. Samples can be sent to the Plant Clinic in Urbana for a thorough diagnosis; call (217) 333-0519, or visit the Web site at http://plantclinic.cropsci.uiuc.edu/. Samples can also be taken to a University of Illinois Extension office to use the Distance Digital Diagnosis System.

Always Read the Label Before Using a Pesticide

The pesticide names used in this publication include both the common, or coined, chemical names and representative trade names. The *common name* is the active ingredient (for example, metalaxyl) and is not capitalized. The *trade name* is a specific company's product name and is capitalized (for example, Allegiance FL). Often, multiple trade names exist for products containing the same active ingredient. In

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The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.

Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.

such cases, the specific company product names have been replaced by the term *many*. Different product combinations and formulas are frequently available. Consult your local agrichemical dealer or Extension office for additional information. **Before making any pesticide-application decision, refer to the most recent product label for application rates, days to harvest, and other information.** The information on a pesticide label can change at any time and may have changed since this chapter was published. According to the Illinois Pesticide Act, a license is required for anyone who purchases or applies restricted-use pesticides. These products clearly state the words "restricted use" on the label. In addition, anyone applying general-use pesticides in the course of employment must have a license. See Chapter 14 for more information about licensing requirements for pesticide application in Illinois.

Fungicide Guidelines

Common Fungicide Terms

A variety of terms is used to describe the mobility and activity of fungicides. Examples include protective-contact, local penetrant, local systemic, translocated, preventive, and curative. Further characterization of the fungicides is shown in Table 3.

Protective-contact fungicides. These products remain on the surface of plant foliage, protecting it from infection for some period. They do not enter the plant tissue. Uniform spray coverage is vital. The length of protection depends on many factors. As with any pesticide, either rainfall or irrigation within a few hours after application may wash away much of the pesticide and greatly reduce the protective value. Even after drying on the plant surface, residues continue to be eroded via rain, dew, vaporization, sunlight, etc., thus reducing protection. Furthermore, as the plant tissues expand or are replaced, new tissue is left unprotected. For these reasons, protective-contact fungicides must be reapplied more often than systemic fungicides. The addition of a spreader–sticker adjuvant to the spray mix may help improve coverage and slow residue loss. As always, carefully read both the fungicide and the adjuvant label to ensure that the proposed tank mix is legal and safe for the crop.

Local penetrant and systemic fungicides. These products are absorbed into the plant. Some are fairly mobile within the plant, while others are not. Local penetrant (sometimes called local systemic) fungicides are absorbed into the immediate area of application but are not translocated far from the site of uptake. They serve to prevent the development of disease at and near the site of absorption. Systemic fungicides are more mobile than local penetrants. However, the systemic fungicides currently available in the field-crops market display only upward/outward mobility in the plant. This upward/outward movement is sometimes referred to as acropetal or apoplastic translocation.

Curative vs. preventive activity. Fungicides can also be classified according to *when* they act upon the pathogen. Preventive fungicides prevent the infection by and establishment of the pathogen. All fungicides offer some degree of preventive activity. Because protective contact fungicides do not enter the plant, it stands to reason that they provide only preventive activity.

Some systemic and local penetrant fungicides have "curative" properties, meaning the fungicide has the ability to stop the progress of infections that may have occurred a few hours or days before the application. This "kick-back" or "reach-back" characteristic is useful when responding to infection episodes. However, the effectiveness of even curative fungicides is diminished when an applicator waits too long and disease severity becomes too high.

Seed Treatments

The greatest benefits of fungicide seed treatments are often found where seed is of low quality due to damage or fungal infestation, where the seedbed is sufficiently cool and wet to delay germination or emergence, and where low seeding rates are used. Fungicide seed treatments are not a substitute for high-quality seed and do not improve the performance of seed that is low in quality due to mechanical damage or physiological factors. Treated seed of low quality usually does not produce stands or yields equal to untreated high-quality seed. Therefore, only seed of high quality should be considered first for planting.

The checklist for soybean seed treatments (Table 4) is designed to assist in determining the need for seed treatments, especially for control of damping-off pathogens. Selection of the proper seed treatment is very important because certain fungicides may be effective for controlling only specific pathogens, such as *Phytophthora* and *Pythium*.

Foliar Treatments

Foliar fungicide treatments may reduce losses due to disease in soybean, corn, and small grains. Foliar sprays of fungicides may maintain yields and seed quality when conditions are favorable for disease development. The use of fungicides should be based on expected disease severity and is most economical for seed-production fields.

The checklist in Table 5 may be used to determine if fungicide controls for pod and stem blight, anthrac-

nose, stem canker, Septoria brown spot, Cercospora leaf blight, or frog-eye leaf spot are warranted. If the checklist is used to determine whether disease severity warrants spraying and fungicides are applied correctly, maximal benefits should be achieved. Refer to Table 2 for Asian soybean rust fungicide recommendations.

Foliar fungicides can be applied to corn to control leaf blights, gray leaf spot, and common and southern rust diseases. The use of fungicides is generally justified only when disease is prevalent within 1 to 2 weeks of tasseling. Infections that begin 1 to 2 weeks after tasseling or later may not cause economic losses and therefore may not warrant a fungicide. Risk factors such as crop rotation and tillage practices (for example, no-tilled corn-on-corn), hybrid susceptibility, and weather conditions all play a role in disease development. Observation of these risk factors, along with scouting, will help in making fungicide application decisions for corn.

Foliar fungicides can be applied to small grains (primarily wheat) to control Fusarium head blight (scab), rusts, Septoria diseases, leaf blights, and tan spot. When inadequate rotations have been used and weather is wetter than normal, these diseases are most damaging from emergence of the flag leaf to early milk stage. Fungicides may increase yields, seed weight, and quality, and reduce deoxynivalenol (DON) toxin levels in harvested grain. Decisions about using fungicides to control foliar diseases should be based on the amount of disease at the emergence of the flag leaf. The Fusarium head blight risk-assessment tool is available to help make fungicide-application decisions for management of Fusarium head blight; this information is on the Web at http://www.wheatscab.psu.edu.

Spray adjuvants (surfactants) help disperse fungicides and improve coverage. If an adjuvant is compatible with the product, it can be added to the spray mix. Adjuvants are especially helpful for corn and small grains. Achieving the best fungicide coverage possible results in better disease control. It is important to use the correct nozzle type and orientation, droplet size, and spray volume to achieve the best coverage and disease control possible for the specific crop and disease. Refer to Chapter 10 for more information regarding application equipment.

Disease Reactions of Field-Crop Varieties Recommended for Illinois

Disease incidence and severity vary from one locality to another and from year to year depending on disease resistance in the crop, the weather and soil conditions, previous disease, and races of the pathogens present. For information on suggested disease-resistant crop varieties, consult your seed dealer; local Extension office; or the Department of Crop Sciences, University of Illinois, AW-101 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801. For soybean variety selection, disease resistance, and other information, resources are available on the Web at the Varietal Information Program for Soybeans (VIPS) site: http://web.aces.uiuc.edu/VIPS/newIndex.cfm. Information on wheat variety disease resistance is available at the University of Illinois Variety Testing Program site: http://vt.cropsci.uiuc.edu/.

Nematicide Application

Granular nematicides/insecticides registered for use on corn and sorghum may be used as in-furrow or band treatments, depending on the product label. Follow the manufacturer's suggestions on application methods. Nematicides should be used only where soil analysis shows high numbers of parasitic nematodes above a threshold value. Follow soil-sampling instructions in *RPD* no. 1100, "Collecting and Shipping Soil Samples for Nematode Analysis." Nematicides are not designed to replace crop rotation or the use of resistant crop varieties in a management program. Successful nematode management is based upon an integrated approach that may include pesticides. Pesticides alone do not provide adequate control and may produce environmental problems.

Recommended Plant Disease Web Resources

http://www.ag.uiuc.edu/~vista/pubs.html
Publications on agriculture and horticulture topics written by University of Illinois faculty and staff. This site contains issues of *Report on Plant Disease.*

http://www.pesticidesafety.uiuc.edu
Pesticide safety education, including information on pesticide applicator training and safe and effective use of pesticides.

http://www.ipm.uiuc.edu/bulletin/index.php/
The online *Pest Management and Crop Development Bulletin* contains pest-management information for diseases, insects, and weeds in Illinois.

http://web.aces.uiuc.edu/VIPS/newIndex.cfm
The Varietal Information Program for Soybeans site contains information on disease-resistance ratings, as well as other traits for soybean varieties.

http://vt.cropsci.uiuc.edu
The University of Illinois Department of Crop Sciences Variety Testing Program contains information on disease-resistance ratings of wheat and alfalfa varieties, as well as performance data from soybean, corn, small grain, and forage crop variety trials conducted each year across the state.

http://www.ipm.uiuc.edu/
The University of Illinois's integrated pest management (IPM) site.

http://cropdisease.cropsci.uiuc.edu/
Basic information to help users recognize, understand, and manage field crop diseases in Illinois.

http://www.apsnet.org/
The American Phytopathological Society's Web site contains extensive information on plant diseases and their control, as well as a catalog of publications on plant diseases.

http://www.plantmanagementnetwork.org/
The Plant Management Network's Web site contains resources for the applied plant sciences. Results from fungicide efficacy trials and variety screening trials for disease resistance can be found here.

http://www.cdms.net/
Current pesticide labels and material safety data sheets.

http://www.greenbook.net
Information on pesticides, including current pesticide labels and material safety data sheets.

http://plantclinic.cropsci.uiuc.edu/
The Web site for the University of Illinois Plant Clinic describes services offered, fees, and directions for submission of plant samples for diagnosis.

http://www.wheatscab.psu.edu
The Fusarium head blight risk-assessment tool. This tool can be used to help determine the risk of Fusarium head blight (scab) occurring in different areas of Illinois and other wheat-producing states.

http://www.sbrusa.net
The Pest Information Platform for Extension and Education (PIPE) Web site contains information about soybean rust observations in the United States.

http://soybeanrust.org
The Illinois soybean rust information center and Illinois sentinel plot system Web site contains information on soybean rust disease and spore observations in Illinois and information on scouting and managing this disease.

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Soybean Rust Fungicide Decision Guidelines

These guidelines were developed by the North Central and Eastern Regional Association of State Agricultural Experiment Station Directors (NCERA–208) Soybean Rust Committee, with the help of land-grant university Extension plant pathologists.

For many of the soybean production regions in North America, the decision to make fungicide applications for management of soybean rust is based on risk. Several factors are involved in the risk of soybean rust moving into an area: incidence and severity of rust in areas to the south, wind patterns that can move the spores of the soybean rust fungus over long distances, regional and local weather, and growth stage of the soybean crop. To determine the risk level of a specific state or province, check with local Extension specialists and the "state commentary" on the PIPE Web site (www.sbrusa.net). An example of a low-risk situation is that of soybean rust in 2006, in which dry conditions in the Gulf Coast states prevented buildup of soybean rust spores early enough to impact the crop in the northern United States and Canada. An example of a moderate-risk situation is a scenario in which soybean rust has been found on soybean in a neighboring state or region but has not yet been detected in your area. Another example of a moderate-risk situation is soybean rust has built up to significant levels in one or more southern states, the long-range forecast is for storm fronts to pass through those areas in the next 2 weeks, and weather is predicted to be suitable for soybean rust in your area. An example of a high-risk situation is soybean rust has been identified in a sentinel plot, commercial soybean field, or kudzu patch in your state or province; and weather conditions are predicted to favor rust development.

Fungicides available for management of soybean rust have different properties that allow them to protect against and control soybean rust. Although all fungicides work best if applied prior to disease onset, some fungicides may also have some "post-infection" properties (aka "curative" or "kick-back" properties). The most effective fungicide classes currently available for soybean rust management are the strobilurin (QoI, quinone-outside-inhibiting, aka Group 11) and the triazole (DMI, demethylation-inhibiting, aka Group 3) fungicides. In general, the triazole fungicides have better movement within the soybean plant and have better "post-infection" properties than the strobilurin fungicides. Strobilurin fungicides tend to have longer residual activity than triazole fungicides and may provide better control of other foliar and stem diseases of soybean. Some pre-mix and co-pack products are available that contain both a strobilurin and a triazole fungicide, and strobilurin and triazole fungicides can be tank-mixed as well.

Soybean Rust Application Recommendations

Vegetative Growth Stages

Current data indicate that fungicide applications are not needed in the early vegetative growth stages for soybean rust control. Applying a fungicide just prior to soybean flowering (R1) may be prudent if disease risk is high. This is especially true for late-planted crops and/or very late-maturing varieties that may develop a large canopy before flowering.

R1 (beginning of flowering) through R5 (beginning seed) reproductive stages. Soybean rust develops most rapidly during soybean reproductive growth stages. The first fungicide application should be made before rust has appeared on more than 10 percent of the leaflets in the canopy. At an incidence this low, each rusted leaflet may have only one or very few pustules, and the disease is difficult to detect without careful scouting. An application of a fungicide when the level of disease is greater than 10 percent incidence may protect newly emerging leaves but may not result in a yield benefit. Prior to applying fungicide to a given field, the field should be checked for the presence and level of rust in the field, as well as other foliar and stem diseases. If other foliar and/or stem diseases are present, then some adjustment of fungicide mix may be needed. Check with local Extension specialists for specific state/province recommendations at this level of disease and for presence of other foliar diseases in the area. In some areas, multiple applications may be needed, depending upon the growth stage when the disease is first detected and the subsequent environmental conditions. Consecutive applications of stand-alone strobilurin or triazole fungicides should not be made, due to the concern of fungicide resistance developing in the soybean rust pathogen. Refer to fungicide labels for specific directions and restrictions.

R6 (full seed) and later. The benefits of applying a fungicide at late growth stages are uncertain. In addition, many fungicides have preharvest-interval restrictions that do not allow applications past R6. Refer to fungicide labels for specific directions and restrictions, and check with local Extension specialists for specific state/province recommendations.

Table 1. Disease-control guidelines for field crops (see product labels for specific, current information)

Crop, disease	Fungicide or nematicide		Comments and recommendations
	Common name	Trade name	
ALFALFA			
Seed rots and seedling blights	captan	many	Seed treatment is often helpful, even with high-quality seed.
	fludioxinil	Maxim XL	
	mefenoxam	Apron XL LS, Ridomil Gold EC	
	metalaxyl	Allegiance FL and LS, Apron FL	
	thiram	many	
Bacterial wilt, Fusarium wilt Phytophthora root rot Aphanomyces root rot			Resistant varieties should be planted.
Leaf spots, spring blackstem, and anthracnose	copper hydroxide	Champ Kocide	Cut forage in a timely manner to reduce leaf loss and maximize yield and quality. Studies have shown inconsistent benefits of using foliar fungicides. Choose varieties with resistance to anthracnose.
Crown and root rots			Maintain proper fertility and soil pH. Avoid harvesting or grazing too often during the last 5 to 6 weeks of the growing season. Control insect pests.
Verticillium wilt			This disease is most often a problem in stands over 3 years old. Plant resistant-varieties.
Sclerotinia crown and stem rot			Use the most resistant varieties, and plant in the spring. The use of 3- or 4-year rotations with nonlegume crops and deep plowing where possible may reduce disease severity.
BARLEY			
Seed rots, seedling blights, loose smut	azoxystrobin	Dynasty	Seed treatment is strongly suggested.
	captan	many	
	carboxin	Vitavax	
	fludioxonil	Maxim XL, FS	
	imazalil	many	
	mefenoxam	Apron XL LS	
	metalaxyl	Allegiance FL and LS, Apron FL	
	PCNB	many	
	tebuconazole + thiram	Raxil-thiram	
	thiram	many	
	triadimenol	Baytan 30	
	triticonazole	Charter	

Table 1. Disease-control guidelines for field crops (cont.)

Crop, disease	Fungicide or nematicide: Common name	Fungicide or nematicide: Trade name	Comments and recommendations
BARLEY (CONT.)			
Barley yellow dwarf virus			Plant winter barley after the Hessian fly–free date and spring barley as early as possible.
CLOVER			
Anthracnose diseases			Grow resistant adapted varieties.
Crown and root rots			Same as for alfalfa.
Seed rots, seedling blights, and Sclerotinia			Same as for alfalfa.
CORN			
Seed rots and seedling blights	azoxystrobin	Dynasty	Sow injury-free, plump seed in noncompacted soils that are at least 50°F. Prepare the seedbed properly and place herbicide, fertilizer, insecticide, and seed correctly. Fungicide seed treatments are commonly used. Dynasty will be applied only in combination with mefenoxam and fludioxonil.
	captan	many	
	carboxin	Vitavax	
	fludioxonil	Maxim 4FS	
	mefenoxam	Apron XL LS	
	metalaxyl	Allegiance	
	thiram	many	
	trifloxystrobin	Trilex	
Northern leaf blight Southern leaf blight Northern leaf spot	azoxystrobin	Quadris	Plant resistant hybrids. Chlorothalonil is registered only for seed corn and sweet corn. Begin applications when conditions favor disease development, and repeat at 4- to 7-day intervals or as required to maintain control.
	chlorothalonil	Bravo	
	mancozeb	Dithane M-45, Manzate 200, Penncozeb	
	propiconazole	Tilt PropiMax EC	Stratego contains propiconazole and trifloxystrobin. Do not make more than 3 applications of strobilurin-containing fungicides (such as Quadris and Stratego) per crop. Also, these fungicides should be applied alternately with fungi- having different modes of action to reduce development of fungicide-resistant pathogens.
	propiconazole + azoxystrobin	Quilt	
	propiconazole + trifloxystrobin	Stratego	
	pyraclostrobin	Headline	
Gray leaf spot	azoxystrobin	Quadris	Gray leaf spot is usually most damaging in no-till continuous corn. Fields located in low-lying areas or areas subject to frequent fogs, high humidity, or irrigation are prone to disease. Plant tolerant or resistant hybrids and use crop rotation and tillage where feasible.
	propiconazole	Tilt PropiMax EC	
	propiconazole + azoxystrobin	Quilt	
	propiconazole + trifloxystrobin	Stratego	
	pyraclostrobin	Headline	
Common rust and southern rust	azoxystrobin	Quadris	Same as for leaf blights and spots. Quadris and Stratego are labeled for control of common rust *(Puccinia sorghi)* only.
	chlorothalonil	Bravo	
	propiconazole	Tilt PropiMax EC	
	propiconazole + azoxystrobin	Quilt	
	propiconazole + trifloxystrobin	Stratego	
	pyraclostrobin	Headline	

Table 1. Disease-control guidelines for field crops (cont.)

Crop, disease	Fungicide or nematicide: Common name	Fungicide or nematicide: Trade name	Comments and recommendations
CORN (CONT.)			
Stewart's disease (a bacterial disease)			Plant resistant hybrids. Insecticides and insecticide seed treatments may be used to control flea beetles when necessary.
Goss's bacterial wilt and leaf blight (a bacterial disease)			Plant resistant hybrids. Clean plowdown and 2-year crop rotations also give control. Use clean plowdown only where erosion is not a problem.
Anthracnose, eyespot	azoxystrobin propiconazole propiconazole +azoxystrobin propiconazole +trifloxystrobin	Quadris Tilt, PropiMax EC Quilt Stratego	Plant resistant or tolerant hybrids. Practice crop rotation or clean tillage where soil-erosion considerations allow. Quadris and Headline are labeled for control of anthracnose leaf blight and eyespot. Propiconazole (PropiMax and Tilt), Quilt, and Stratego are labeled for control of eyespot but not anthracnose.
Physoderma brown spot, yellow leaf blight	pyraclostrobin	Headline	See management for anthracnose and eyespot.
Crazy top and sorghum downy mildew			Plant resistant or tolerant hybrids. Improve drainage in affected area. Control wild cane to reduce sorghum downy mildew inoculum.
Viral diseases			Plant resistant hybrids. Control johnsongrass to reduce overwintering source of maize dwarf mosaic and maize chlorotic dwarf viruses.
Stalk rots (charcoal, *Diplodia, Fusarium, Gibberella, Nigrospora,* anthracnose)			Plant hybrids with good stalk rot resistance and stalk strength. Maintain adequate nitrogen, phosphorus, and potassium fertility. Control corn borers and corn rootworms. Scout fields at 30 to 40% moisture for lodging potential. Walk a zigzag pattern through the field, pushing random plants about 5 inches from the vertical. If more than 10 to 15% lodge, schedule the field for early harvest.
Storage molds *Aspergillus* spp. *Penicillium* spp.	propionic acid		Grain treated with an acid grain preservative may be used only for animal feed. Store undamaged corn at 15 to 15.5% moisture from fall until spring, then dry to 13% for long-term storage. Grain damaged by field molds, insects, and the like should be dried to 13 to 13.5% moisture at harvest. Watch stored grain for heating, musty odor, crusting, or other signs of storage mold activity. Control stored-grain insects. Make sure the combine is adjusted to avoid damage to grain. Remove fines and foreign material before storage.

Table 1. Disease-control guidelines for field crops (cont.)

Crop, disease	Fungicide or nematicide: Common name	Fungicide or nematicide: Trade name	Comments and recommendations
CORN (CONT.)			
Nematodes Dagger Lance Ring Root-knot	ethoprop terbufos	Mocap Counter	Use nematicidal rates of these materials only when soil tests indicate populations of nematodes are above threshold. Eliminate pH, fertility, hardpan, soil insects, and other diseases as possible limiting factors before using nematicides.
Root-lesion Spiral Sting Stubby-root Stunt			More than one genus of plant-parasitic nematode may be present in a field. Identification of nematodes should be done before selecting rotation.
Needle			Use crop rotation where appropriate. For needle nematode control, avoid small grains in rotations and control grassy weeds.
OATS			
Seed rots and seedling blights	captan carboxin fludioxonil mefenoxam metalaxyl PCNB tebuconazole + thiram thiram triadimenol	many Vitavax Maxim 4FS Apron XL LS Allegiance FL and LS, Apron FL many Raxil-thiram many Baytan 30	Seed treatment is strongly suggested for control of smut diseases. Carboxin, PCNB, tebuconazole, and triadimenol have efficacy against smut diseases.
Barley yellow dwarf			Grow resistant varieties. Plant susceptible varieties as early in the spring as possible.
Rusts	propiconazole	PropiMax Tilt	Plant resistant varieties. Fungicides applied for *Septoria* and *Helminthosporium* also aid in crown rust control.
SORGHUM			
Seed rots, seedling blights, and smuts	captan fludioxonil mancozeb mefenoxam PCNB thiram	many Maxim 4FS Dithane M-45, Manzate 200, Penncozeb Apron XL many many	Fungicide seed treatment is strongly suggested. Plant in soils at least 60° to 65°F.

Table 1. Disease-control guidelines for field crops (cont.)

Crop, disease	Fungicide or nematicide: Common name	Fungicide or nematicide: Trade name	Comments and recommendations
SORGHUM (CONT.)			
Nematodes	aldicarb terbufos	Temik Counter	Apply only where soil analysis indicates an economic nematode population. Eliminate pH, fertility, hardpan, soil insects, and other diseases before using nematicides. Crop rotation may be practical only after identifying the nematodes involved.
SOYBEANS			
Seed rots and seedling blights (primarily *Fusarium, Pythium, Phytophthora,* and *Rhizoctonia)*	azoxystrobin azoxystrobin + metalaxyl *Bacillus pumilis* captan carboxin fludioxonil mefenoxam metalaxyl PCNB thiabendazole thiram trifloxystrobin	Dynasty SoyGard Yield Shield many Vitavax Maxim 4FS Apron XL LS Allegiance FL and LS many TBZ many Trilex	Plant high-quality seed germinating more than 70% in a cold germination test. Seed treatment is recommended when seed of unknown quality due to fungal infection must be planted, delays in emergence are anticipated, seed is planted to produce seed, reduced seeding rates are used, or seed is planted into wet soil or heavy crop residue (reduced tillage or no-till). Plant in soils that are at least 55°F. Apron XL L and Allegiance FL control *Pythium and Phytophthora.*
Charcoal rot			Plant full-season varieties as early as possible. Avoid excessive seeding rates and maintain optimal fertility. Deep fall plowing may be beneficial where soil erosion concerns allow.
Brown stem rot			Rotate, using 2 years of corn where brown stem rot has been a problem. Plant varieties labeled tolerant, resistant, or moderately resistant. Control soybean cyst nematode.
Sclerotinia white mold	*Coniothyrium minitans* tetraconazole thiophanate-methyl	Contans WG Domark 230 ME Topsin-M	Rotate with nonlegume crops. Plant moderately resistant varieties in fields where disease has been present before. Corn and small grains are not affected by white mold. Fungicides must be directed into the lower canopy for control. Some fungicide seed treatments have been shown to reduce potential for seedborne distribution. A biological control product (Contans WG) contains a fungus that can destroy sclerotia of the white mold fungus in the soil.

Table 1. Disease-control guidelines for field crops (cont.)

Crop, disease	Fungicide or nematicide: Common name	Fungicide or nematicide: Trade name	Comments and recommendations
SOYBEANS (CONT.)			
Phytophthora root rot	mefenoxam	Apron XL, Ridomil Gold	Plant varieties with race-specific or field resistance (tolerance). Race-specific resistance with Rps genes provides immunity to specific races. In some areas, races of the *Phytophthora* fungus are present that can attack this type of resistance. In this case, varieties with field tolerance should be planted. All varieties should be protected in the seedling stage with Apron XL LS or Allegiance FL fungicide applied as a seed treatment.
	metalaxyl	Allegiance	
Nematodes			
Soybean cyst nematode (SCN)			Use SCN-resistant varieties. The same resistant soybean varieties should not be grown in the same field twice. Monitor SCN populations by taking soil samples. Maintain proper soil samples. Maintain proper soil fertility. Rotate with nonhost crops, such as corn or small grains.
Root-lesion Dagger Lance Root-knot Spiral Sting Stubby-root Stunt			No soybean varieties are resistant to root-lesion nematodes, so crop rotation and nematicides are the most practical approaches to control.
Sudden death syndrome (SDS)			Some varieties have partial resistance to SDS. Plant more than one variety where SDS has been a problem and stagger planting dates. Early-planted soybeans are frequently more severely damaged than later-planted ones. Vary maturity by planting more than one maturity group or use different maturities within a single group. Infection is influenced by cool and wet weather. Control soybean cyst nematode.
Pod and stem blight, anthracnose, stem canker, Septoria brown spot, Cercospora leaf blight, purple seed stain, frogeye leaf spot	azoxystrobin	Quadris	Plant resistant varieties if available. Fungicides may be warranted when conditions are favorable for these foliar diseases (see Table 3). Fungicides are not labeled for control of stem canker. Domark and Tilt are not labeled for control of pod and stem blight, and Tilt is not labeled for control of Cercospora blight. Do not graze or feed treated soybean vines to livestock.
	chlorothalonil	Bravo	
	propiconazole	Tilt	
	propiconazole + azoxystrobin	Quilt	
	propiconazole + trifloxystrobin	Stratego	
	pyraclostrobin	Headline	
	tetraconazole	Domark	
	thiophanate-methyl	Topsin-M	

Table 1. Disease-control guidelines for field crops (cont.)

Crop, disease	Fungicide or nematicide: Common name	Fungicide or nematicide: Trade name	Comments and recommendations
SOYBEANS (CONT.)			
Soybean rust	**See Table 2 for soybean rust fungicides.**		Check state reports and soybean rust observations in the United States at http://www.sbrusa.net/. Refer to the soybean rust fungicide decision guidelines (Table 2).
WHEAT			
Seed rots, seedling blights, loose smut, and bunt (stinking smut)	azoxystrobin	Dynasty	Seed treatment is strongly suggested. Thiram or captan alone does not control loose smut. A number of products contain various combinations of these fungicides. Many different fungicidal products are available for treatment of wheat seed, and this list is intended to provide examples of products available.
	captan	Captan	
	carboxin	Vitavax	
	difenoconazole	Dividend XL	
	difenoconazole + mefenoxam	Dividend Extreme	
	fludioxinil	Maxim XL	
	imazalil	many	
	mancozeb	Grain Guard	
	mefenoxam	Apron XL LS	
	metalaxyl	Allegiance FL and LS, Apron FL	
	mefenoxam	Apron XL LS	
	PCNB	many	
	tebuconazole + thiram	Raxil-thiram	
	thiabendazole	TBZ	
	thiram	many	
	triadimenol	Baytan 30	
	triticonazole	Charter	
Septoria leaf blotch, Stagnospora glume blotch, Helminthosporium leaf blight, Pyrenophora tanspot	azoxystrobin	Quadris	Plant resistant varieties. Apply fungicide when disease conditions warrant. Quadris is not labeled for *Helminthosporium*.
	mancozeb	Dithane M-45, Manzate 200, Penncozeb	
	propiconazole	Tilt	
	propiconazole + azoxystrobin	Quilt	
	propiconazole + trifloxystrobin	Stratego	
	prothioconazole	Proline	
	pyraclostrobin	Headline	
Leaf rust, stripe and stem rust	azoxystrobin	Quadris	Product labels should be consulted for allowable number of applications and growth stage (Feekes' stage) when last application is allowed. Proline is not labeled for control of stripe rust.
	propiconazole	Tilt	
	propiconazole + azoxystrobin	Quilt	
	propiconazole + trifloxystrobin	Stratego	
	prothioconazole	Proline	
	pyraclostrobin	Headline	
	triadimenol	Baytan 30	

Table 1. Disease-control guidelines for field crops (cont.)

Crop, disease	Fungicide or nematicide		Comments and recommendations
	Common name	Trade name	
WHEAT (CONT.)			
Powdery mildew	azoxystrobin	Quadris	Plant resistant varieties.
	propiconazole	Tilt	
	propiconazole + azoxystrobin	Quilt	
	propiconazole + trifloxystrobin	Stratego	
	pyraclostrobin	Headline	
	triadimenol	Baytan 30	
Take-all			Plant after the Hessian fly–free date. Use ammonium form of nitrogen fertilizer. Use crop rotations of 2 to 3 years between wheat crops where possible.
Fusarium head blight (scab)	prothioconazole	Proline	Choose resistant varieties and plant varieties with different maturities. Wheat planted into corn or wheat stubble may be at a higher risk for scab. Consult the Fusarium head blight risk-assessment tool at http://www.wheatscab.psu.edu to determine if your area is at risk for scab.
Viral diseases			
Wheat streak mosaic, wheat soilborne mosaic			Plant resistant or tolerant varieties. Plant after the Hessian fly–free date. Control volunteer wheat in and around production fields.
Barley yellow dwarf, wheat spindle streak mosaic			Insecticide seed treatments may help reduce barley yellow dwarf virus by controlling aphids.

Table 2. Foliar fungicides available for control of rust on soybean in Illinois (as of 9/14/07)

Trade name	Active ingredient(s)	FRAC code(s)[a]	Rate per acre	PHI[b]	Label status[c]	Section 18 expiration	Company
Alto	cyproconazole	3	4 fl oz	30 days	section 18	4/19/09	Syngenta Crop Protection
Caramba	metconazole	3	8.2–9.6 fl oz	30 days	section 18	4/19/09	BASF Corporation
Domark 230 ME	tetraconazole	3	4–5 fl oz	not after R5	section 3	N/A[d]	Valent USA
Folicur	tebuconazole	3	3–4 fl oz	30 days	section 18	11/10/07	Bayer CropScience
Laredo EC	myclobutanil	3	4–8 fl oz	28 days	section 3	N/A	Dow AgroSciences
Laredo EW	myclobutanil	3	4.8–9.6 fl oz	28 days	section 3	N/A	Dow AgroSciences
Orius	tebuconazole	3	3–4 fl oz	30 days	section 18	11/10/07	Mahteshim-Agan
Punch	flusilazole	3	3–4 fl oz	30 days	section 18	6/15/10	DuPont
Tilt	propiconazole	3	4–6 fl oz	up to R6	section 3	N/A	Syngenta Crop Protection
Topguard	flutriafol	3	7 fl oz	21 days	section 18	5/11/10	Cheminova
Uppercut	tebuconazole	3	3–4 fl oz	30 days	section 18	11/10/07	DuPont
Headline	pyraclostrobin	11	6–12 fl oz	21 days	section 3	N/A	BASF Corporation
Quadris	azoxystrobin	11	6–15.5 fl oz	14 days	section 3	N/A	Syngenta Crop Protection
Headline SBR	tebuconazole + pyraclostrobin	3, 11	5.8–7.8 fl oz	30 days	section 18	11/10/07	BASF Corporation
Quadris Xtra	cyproconazole + azoxystrobin	3, 11	4 fl oz	30 days	section 18	4/19/09	Syngenta Crop Protection
Quilt	propiconazole +azoxystrobin	3, 11	14–20.5 fl oz	21 days	section 3	N/A	Syngeta Crop Protection
Stratego	propiconazole + trifloxystrobin	3, 11	7–10 fl oz	21 days	section 3	N/A	Bayer CropScience
Bravo Ultrex	chlorothalonil	M	0.9–2.2 lb	42 days	section 3	N/A	Syngenta Crop Protection
Bravo WeatherStik	chlorothalonil	M	1–2.25 pt	42 days	section 3	N/A	Syngenta Crop Protection
Echo 720	chlorothalonil	M	1–2.5 pt	42 days	section 3	N/A	Sipcam
Echo 90 DF	chlorothalonil	M	0.9–2 lb	42 days	section 3	N/A	Sipcam
Equus 720 SST	chlorothalonil	M	1–1.6 pt	42 days	section 3	N/A	FarmSaver
Equus DF	chlorothalonil	M	1.5–2.2 lb	42 days	section 3	N/A	FarmSaver

[a]FRAC codes developed by the Fungicide Resistance Action Committee. Fungicides with the same code have the same site of action. For more information, go to http://www.frac.info.
[b]PHI = preharvest interval.
[c]Section 18 emergency exemptions are good for the state of Illinois only, and products with section 18 exemptions can be applied only for soybean rust control. A copy of the section 18 emergency exemption use directions must accompany the applicator.
[d]N/A = not applicable.

Table 3. Fungicide Resistance Action Committee (FRAC) Group, fungicide names, resistance risk, and mobility for fungicides used in Illinois field crops[a]

FRAC Group code and name [target site of action]	Common name	Trade names	Resistance risk	Mobility
1. methyl benzimidazole carbamites [mitosis: B-tubuline assembly]	thiabendazole	LSP, in Rival	high	systemic (upward)
	thiophanate-methyl	Topsin-M	high	systemic (upward)
3. demethylation inhibitors (DMI) [C14-demethylation in sterol biosynthesis]	difenoconazole	Dividend	medium	systemic (upward)
	imazalil	Flo-Pro IMZ, in Raxil MD Extra	medium	systemic (upward)
	myclobutanil	Laredo	medium	systemic (upward)
	propiconazole	Bumper, PropiMax, in Quilt, in Stratego, Tilt	medium	systemic (upward)
	tebuconazole	Folicur, in Gaucho XT, Orius, in Raxil	medium	systemic (upward)
	tebuconazole	Domark	medium	systemic (upward)
	triadimenol	Baytan	medium	systemic (upward)
4. phenylamides [RNA polymerase I]	mefenoxam (= metalaxyl-M)	Apron XL LS, in Maxim XL, Ridomil Gold	high	systemic (upward)
	metalaxyl	Allegiance	high	systemic (upward)
7. carboximides [complex II in fungal respiration (succinate-dehydrogenase)]	carboxin	in Prevail, Vitavax	medium	systemic (upward)
11. quinone outside inhibitors (QoI) [complex III of fungal respiration: ubiquinol oxidase, Qo site in mitochondria]	azoxystrobin	Dynasty, Protégé, Quadris, in Quilt, in SoyGard	high	systemic (upward)
	pyraclostrobin	Headline	high	local penetrant
	trifloxystrobin	in Stratego, Trilex	high	local penetrant

Table 3. Fungicide Resistance Action Committee (FRAC) Group, fungicide names, resistance risk, and mobility for fungicides used in Illinois field crops[a] (cont.)

FRAC Group code and name [target site of action]	Common name	Trade names	Resistance risk	Mobility
12. phenylpyrroles [MAP protein kinase in osmotic signal transduction]	fludioxonil	Maxim 4FS, in Maxim XL	low to medium	contact-protective
14. aromatic hydrocarbons (chlorophenyls, nitroanilines) [lipid peroxidation (proposed)]	PCNB	in Prevail, Terra-Coat LT-2N, in Vitavax-PCNB	low to medium	contact-protective
M3. dithiocarbamates [multisite contact activity]	mancozeb	Dithane, Manzate, Penncozeb	low	contact-protective
	maneb	in Enhance Plus	low	contact-protective
	thiram	Thiram, in many products	low	contact-protective
M4. phthalimides [multisite contact activity]	captan	Captan, in many products	low	contact-protective
M5. chloronitriles (phthalonitriles) [multisite contact activity]	chlorothalonil	Bravo, Echo, Equus	low	contact-protective

[a]Fungicide labels change frequently; check product labels and consult with manufacturers for current registration and crop use information.

Table 4. Soybean seed-treatment checklist for reducing early-season stand losses due to damping-off

Risk factor	Points for *yes*
Rainfall for the 7-day period before planting	
Below normal	2
Normal	1
Above normal	4
Seedbed preparation	
Conventional tillage	1
Rough surface (conservation tillage)	2
No-till	4
Germination at time of planting is less than 85% in a warm test or less than 70% in a cold test (discard such seed if at all possible)	3
Previous soybean stand in field was reduced by damping-off	4
Level of resistance to Phytophthora root rot	
Susceptible	3
Tolerant	4
Resistant to one or more races	1
Expected rainfall for 6 days following planting	
Below normal	1
Normal	1
Above normal	3
Low areas of field remain flooded for 48 hours following 1 inch of rainfall	4
Seeding rate is less than 55 lb per acre	3
Field is planted to double-crop soybeans	3
*Your total score:*_____	

< 7 points: Seed treatment probably will not be beneficial.
7–15 points: Seed treatment may be beneficial if weather conditions do not favor rapid germination and growth.
> 15 points: Seed treatment will be beneficial to stand development.

Table 5. Checklist to determine if foliar diseases may be a problem in soybeans and if foliar fungicides should be considered

Risk factor	Points for *yes*
Rainfall, dew, and humidity up to early bloom and pod set	
Below normal	0
Normal	2
Above normal	4
Soybeans were grown in the field last year	3
Chisel-plow, disk, or no-till was used	1
Pycnidia (black specks) are visible on more than two-thirds of brown, fallen petioles, and Septoria brown spot is obvious on the lower leaves	2
Early-maturing variety (not full-season)	2
Soybeans are to be used or sold for seed	6
Yield potential is better than 35 bushels per acre	2
Seed quality at planting time is less than 85% germination in a warm test	1
Other conditions favor disease development (weather forecast with a 30-day period of greater-than-normal rainfall and a field history of disease)	3
Your total score: _____	

For a total score of 15 or more, uncontrolled disease may decrease yields and lower seed quality.

Table 6. Soybean rust fungicide-decision guidelines

	Soybean rust status *(Risk determined by national, regional, and local activity and disease forecast.)*					
	Rust absent			Rust present		
	Soybean rust risk[a]			Barely detectable in lower canopy[b]		Easy to detect in mid- to upper canopy
Crop stage	*Low*	*Moderate*	*High*	*First application*	*Second application (if needed)*	
Vegetative (stages before flowering)	***Fungicide application not recommended soybean rust control.***					Yield benefit from fungicide application is uncertain.[d]
R1 (beginning of flowering) through	Do not spray.	Strobilurin	Premix, tank mix, co-pack Triazole	Premix, tank mix, co-pack, or Triazole	Triazole or premix,[c] tank mix, or co-pack	
R5 (beginning seed)	Do not spray.	Triazole Premix, tank mix, co-pack	Triazole			Check with local Extension specialists for specific guidelines.
R6 (full seed) to R8 (full maturity)	Generally, fungicide application is not recommended. Yield responses beyond R6 are uncertain and many fungicide labels specify that applications be made prior to R6. Check with local Extension specialists for specific recommendations for your state or province.					

[a]Determine risk by staying current with information from Extension specialists, trusted industry contacts, and/or crop consultants for the region and state. View the Soybean Rust PIPE Web site (www.sbrusa.net) frequently for updates.
[b]Soybean rust incidence less than 10%.
[c]Premix, tank-mix, or co-pack fungicide should contain the full rate of the triazole fungicide component.
[d]Application of a fungicide at this level of disease may protect newly emerging leaves but may not result in a ield benefit. Check with local Extension specialists for recommendations specific to our state or province.

5

Insect Pest Management for Stored Grain

Key Points for 2007

- Actellic 5E remains registered as the key protectant insecticide for use on stored corn as an admixture during binning or a topdress application to the grain surface. Other insecticides that can be used on stored corn in a similar manner include Diacon II and products containing diatomaceous earth or *Bacillus thuringiensis*. Additionally, a 6 percent malathion dust remains registered and available for purchase for use on stored corn. See the text and table in this chapter for details.
- Storcide II has replaced Reldan and Storcide. See Table 1 for application instructions. Storcide II contains chlorpyrifos-methyl and deltamethrin, a pyrethroid for which international Codex MRLs (maximum residue limits, roughly the same as tolerances) have been established on certain grains. Storcide II is labeled for use on the same small grains that previously were listed on the Reldan label.
- Although the USEPA has granted a residue tolerance for the active ingredient spinosad on several stored grains and international Codex MRLs have been established, those MRLs have not yet been accepted by all countries. Commercialization of spinosad products for use on stored grains is not likely before 2009
- The only malathion product labeled for direct use on small grains and still available for purchase is a 6 percent dust. Its label allows use on corn, barley, oats, rice, rye, sorghum, sunflower seeds, and wheat.
- Relatively new fumigants that are labeled for use in grain storages include ECO_2fume, which is a mixture of 2 percent phospine gas in carbon dioxide, and ProFume, which is the fumigant gas sulfuryl fluoride. These fumigants are not designed for use by farmer applicators but instead by professional fumigators.

Introduction

Grains produced in Illinois may be stored for periods of a few weeks to a few years before they are fed or processed. The profitability of such storage depends not only upon marketing concerns but also upon maintaining grain quality. The harvest and storage of grain do not signal an end to the possibility of losses caused by insects and pathogens.

Successful management of stored-grain insects is possible only when proper storage practices are implemented. Insecticides and fumigants should be viewed as supplements to, not replacements for, sound storage methods. When used properly, insecticides and fumigants limit insect losses in stored grains without endangering the pesticide applicator or resulting in excessive pesticide residues that threaten the health of consumers (livestock or humans) of treated grain or grain products.

This chapter provides recommendations for cultural and chemical control of stored-grain insects. It is revised annually; always use the current year's handbook. Changes in registration that occur between revisions will be announced to appropriate media sources and to Extension offices.

The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.

Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.

Developing an Insect-Management Program for Stored Grain

If grain will be stored on the farm, one goal should be to keep it relatively insect-free, preferably without using insecticides or fumigants. Taking steps to prevent a buildup of insect numbers requires time and planning, but the outcome is grain that is not infested with insects and will not be docked.

The following insect-management tactics should be considered for *preventing* infestations of insects in stored grains. If successful management is achieved with these tactics, fumigation of grain can be avoided.

- Sanitation (cleanup of old grain and grain debris)
- Empty-bin spray with an insecticide
- Empty-bin fumigation, primarily to control insects in the subfloor plenum
- Storing clean, dry grain
- Treating grain with a protectant insecticide
- Aeration to cool the grain to prevent insect feeding and reproduction
- Regular measurement of grain temperature and sampling for insects

If fall-harvested crops (corn, soybean, and grain sorghum) are to be removed from storage by May or June the year after harvest, the nonchemical tactics listed above should be adequate to prevent infestation by stored-grain insects. Empty-bin sprays, empty-bin fumigation, and protectant insecticides probably will not be necessary.

Because wheat is harvested in midsummer, when warm temperatures enable insects to develop and reproduce rapidly, it is more vulnerable to insect infestation. However, if wheat will not be stored for more than one month, the probability for a significant buildup of stored-grain insects is relatively low, so nonchemical management tactics should be sufficient.

All grains stored long term probably will become infested with stored-grain insects. However, implementing an insect-prevention program using the tactics previously listed should lower the probability and intensity of infestation. If an insect infestation develops and fumigation becomes necessary, we recommend employing a professional fumigator. The legal and safety requirements for fumigating stored grain make the expense and risk more than most farmers are prepared to accept.

Using Insecticides and Fumigants

The USEPA has designated certain pesticides for "restricted" use. The fumigants aluminum phosphide (alone or in combination with carbon dioxide), sulfuryl fluoride, and chloropicrin are restricted use pesticides. *Commercial* applicators must be certified to apply restricted use pesticides. Elevator employees responsible for grain treatment at their place of employment must be certified under the category Grain Facility Pest Control Applicator. Commercial fumigation professionals who treat stored grain or grain products at farms, elevators, or warehouses must be certified by the Illinois Department of Public Health. A *private* applicator who wishes to purchase or apply restricted use pesticides "for the purpose of protecting any agricultural commodity on property owned or rented by him or as exchange labor (no compensation) on the property of another" must obtain certification by passing an examination administered by the Illinois Department of Agriculture. *Regulations enacted by the Illinois Department of Agriculture mandate that private applicators must obtain special certification to purchase and apply grain fumigants.* ***To obtain certification for fumigant application, individuals must first pass the private applicator exam and then pass a grain storage and fumigation exam.*** For information about training materials, contact Scott Bretthauer in the Department of Agricultural and Biological Engineering, 360 AESB, 1304 W. Pennsylvania Ave., Urbana, IL 61801, (217)333-9418.

Persons who apply pesticides should be aware that the applicator is always responsible for the results of pesticide applications. To avoid accidents and maximize the effectiveness of any application, always read the pesticide label and follow all directions and safety precautions. Be sure that the pesticide is specifically labeled for the pest, site, and application method planned. *The label is the law.*

Insects Attacking Stored Grain

Several types of insects inhabit stored grain. Identification is often difficult because most stored-grain pests are small (1/16 to 1/4 inch long), and many species are similar in appearance. Information about identifying the many species of stored-grain insects is not presented here; see instead the reference list at the end of this chapter. It is important, however, to recognize the different groups of insects that live in stored grains because management considerations may differ according to the insects' characteristics and behavior. Different species vary significantly in their potential to cause economic damage, and some insects cause no damage to stored grain.

Weevils and Other Insects That Feed Inside Kernels

Primary insect pests of stored grain develop within grain kernels and can destroy whole, sound grain. Adults deposit eggs on or in whole kernels, and larvae develop inside the kernels. Feeding by these insects causes grain to be classified as sample grade.

The primary pests found in stored grain in Illinois are the weevils—rice weevil, maize weevil, and granary weevil. The grain weevils are small (between 1/16 and 1/8 inch long) but recognizable as a group because the head projects forward as a prolonged snout. Another primary pest found in wheat, but only rarely in corn, is the lesser grain borer. The adult's head projects downward, not forward, and does not bear a snout. These insects may be found in any portion of the grain mass within a bin.

The Angoumois grain moth lays its eggs on grain kernels, and the larvae bore into the kernels and feed there. Although this insect may attack grain before harvest, most of the damage occurs in stored grain. Infestations in storage are limited to the surface of the grain mass. However, this insect only infrequently infests stored grains in Illinois.

Beetles That Develop and Feed Outside Grain Kernels

Most insects commonly collected in stored grain in Illinois are beetles that range in size from 1/16 inch to more than 1/2 inch long. Adults of most species are red–brown to black, and their forewings are hardened to form a "shell" over the body. Larvae of common species are cylindrical and cream colored; some bear fine hairs. Species frequently collected in Illinois grain bins include the sawtoothed grain beetle, flat grain beetle, rusty grain beetle, foreign grain beetle, hairy fungus beetle, larger black flour beetle, red flour beetle, and confused flour beetle.

Like the weevils, beetles that feed and develop outside grain kernels may inhabit any portion of a grain mass. They feed on bits and fragments of several different grains; their buildup usually results from an abundance of broken kernels (fine material) or fungal growth on moist grain. Their dependence on fines or fungal growth accounts for the description of these insects as secondary pests, "bran bugs," or "fungus feeders."

Surface-Feeding Caterpillars

Most caterpillars that feed in stored grain inhabit primarily the outer portions of the grain mass (usually the grain surface, but also the bottom of the mass just above perforated drying floors or aeration ducts). These caterpillars are cream colored and about 1/2 inch long when mature. They produce fine, silken webbing as they move about near the grain surface. Mature larvae pupate within a silky cocoon. Adult moths fly and mate in the bin headspace, where they may be seen resting on the bin walls and roof.

The Indianmeal moth is the most common surface-feeding caterpillar in stored grain in Illinois. The larvae may web over the grain surface completely, thus preventing proper aeration or fumigation. The adult Indianmeal moth has a wingspan of about 3/4 inch; the outer half of each front wing is red–brown or copper colored. Malathion resistance is common in Illinois populations of Indianmeal moth. Other surface-feeding caterpillars include the Angoumois grain moth (which feeds within kernels), the Mediterranean flour moth, and the meal moth.

Other Stored-Grain Insects

Other pests that sometimes infest stored grains include psocids (booklice) and grain mites. These soft-bodied pests feed on fungi. An abundance of psocids or grain mites often indicates a more important problem of mold-related deterioration of the grain.

Not all insects in grain are pests. Parasitic wasps, larvae of a predaceous fly species, and predaceous Hemipterans (true bugs) attack certain grain pests. In addition, many field insects, such as European corn borers and sap beetles, are transported inadvertently to grain bins, where they cause no damage.

Preventing Insect Infestations

Sources of Infestations

Most infestations of stored-grain insects originate from immigration of the insects into the bin from outside. All species of stored-grain insects have numerous food sources on which they survive when stored products are not available. However, large amounts of stored grain are attractive to these pests, and they invade the bins through any available opening.

Other common sources of stored-grain insects are old grain, grain spills, feeds, seed, and grain debris. Insects often move to new grain from carryover grain, from grain not cleaned from "empty" bins, from feed-supply buildings, and from grain debris beneath perforated bin floors.

Some stored-grain insects infest maturing grain in the field. Although some field infestations probably occur in Illinois, the extent of field-originated storage problems is minor.

Sanitation

To minimize the movement of insects from old grain and grain debris to new grain, thorough cleanup is necessary. At least 2 weeks before storing new grain, clean all grain and grain debris from within and

around grain bins. Be thorough; sweep or vacuum bin floors and remove and feed or destroy any grain and grain debris in combines, wagons, and augers. If grain debris is not removed from the combine, collect and feed or destroy the first few bushels of grain that pass through the combine.

Bin Sprays

Insects may remain in certain bin locations even after a thorough cleanup. Hard-to-clean sites that harbor insect pests include cracks and crevices in bin walls and the plenum beneath nonremovable perforated floors. Consequently, application of a residual insecticide should help eliminate lingering infestations of stored-grain insects. Residual sprays also create a barrier for insects that may migrate into a storage area from outside. Applying an insecticide or a fumigant in an empty bin can supplement (but not replace) physical cleanup efforts.

Apply an insecticide to the floor and up to 15 feet up the walls of all bins that will be used to store grain for more than a few weeks during warm weather. Also spray the outside of the bin from the base to a height of 3 feet and treat the ground and vegetation in a 3-foot border around the bin. The best time to apply a residual spray is 2 to 3 weeks before new grain will be stored in the bin. Use one of the following products:

- 8 milliliters of Tempo 2E (cyfluthrin) per 1,000 square feet in sufficient water to cover the area being treated but not to allow dripping or runoff to occur (see product label). *Do not apply directly to grain.*
- 1.8 fluid ounces of Storcide II (a combination of the active ingredients chlorpyrifos-methyl and deltamethrin) per gallon of water. Apply 1 gallon of spray mixture per 1,000 square feet of bin wall or floor surface. Do not apply Storcide II to bins that will be used to store corn or soybean.
- diatomaceous earth (see product label for application rate of the formulation to be used).

Unless labels specify otherwise, spray bin surfaces to the point of runoff and be sure to treat all cracks and crevices and areas around doors thoroughly. Note and follow all label directions for application methods, protective equipment, and reentry.

Filling the Bin

Effective insect management in stored grain requires good storage practices. Use a grain cleaner to minimize the amount of fine material that is binned with the grain. Many species of stored-grain insects cannot survive in the absence of broken kernels and grain debris. Use of a grain spreader evenly distributes remaining fine material and helps to level the grain surface. After the bin is full, if fine material is concentrated in a central core beneath the auger spout, removing one or a few loads from the bin will extract this core of fines. Periodic removal of the center core during the bin-filling process is even more effective for extracting fines. Do not add new grain on top of old because insects will move from the infested grain to the new grain. Do not overfill bins; the leveled grain surface should be at least a few inches below the lip of the bin. Leveling the grain surface is important for uniform airflow and for effective application of insecticide or fumigant.

Store only dry grain. Maintaining moisture levels that prevent the growth of storage fungi is sufficient where fall-harvested grain is to be stored only through the winter. *Wheat that will be stored 1 month or longer during warm summer weather should be dried to 12 to 13 percent moisture; corn should be dried to 14 to 15 percent moisture.*

Aerate to cool stored grain as soon as possible. Temperatures below 50°F prevent insect feeding and reproduction. Cooling grain to just above freezing kills some stages of many grain insects. Cooling grain to 10° to 15°F will kill nearly 100 percent of common stored-grain pests. Aeration also results in uniform temperatures that prevent moisture migration problems within a bin. Most grain-storage references recommend aerating to maintain grain temperatures within 15°F of average outdoor temperatures, however, it is unnecessary to aerate to rewarm grain above 50°F.

Grain Protectants

Application of insecticides directly to grain to prevent infestation may be warranted if grain is to be stored for more than 3 to 6 weeks at grain temperatures above 60° to 70°F. Summer-harvested grains that will be stored 1 month or longer and fall-harvested grains that will remain in storage beyond May or June of the year after harvest should be treated with a protectant insecticide. Incorporating a surface treatment is adequate for short-term protection. However, uniform application to all grain at the auger is necessary for long-term protection. If grain-protectant insecticides are applied at labeled rates, grain may be processed or fed to livestock with no waiting period.

To protect against stored-grain beetles and weevils throughout the entire mass of grain within a bin, apply a protectant insecticide to grain as it is augered

into the bin. Spray-on applicators may be mounted on the auger to apply liquid formulations. Dusts may be spread over a load of grain in a truck or wagon just before unloading. Protectant insecticides should not be applied to grain before high-temperature drying. A "topdress" or "cap-off" treatment may be used to give some control of insects entering the top of the grain mass. If stirrators are used after a topdress application, the surface of the grain mass will no longer be protected. Table 1 summarizes the uses for registered grain protectants.

Crop-specific recommendations for the use of protectant insecticides are described in the subsequent sections.

Corn

It is not necessary to apply any insecticide to new-crop corn that will be removed from storage by May or June of the following spring. Similarly, if corn will be used on-site as livestock feed (and not subject to grading associated with sale) within 1 year of harvest, a protectant insecticide usually is not necessary. For storage periods of 1 year or longer, apply Actellic at the loading auger, using rates listed in Table 1. *Reldan is not registered for use on corn.* Do not apply insecticides before high-temperature drying because extreme heat results in rapid volatilization of the insecticide and reduction in residues. For Actellic residues to persist on corn at effective levels through the summer after harvest, corn must be dried to approximately 14 to 15 percent moisture.

If the grain mass is not treated, surface topdressing or cap-off applications of protectant insecticides are effective against insects that feed at the grain surface. Actellic, *Bacillus thuringiensis (Bt)*, Diacon II, and diatomaceous earth may be applied to corn and incorporated into the top 4 to 6 inches of the grain mass by raking. Actellic, Diacon II, and diatomaceous earth are labeled for use against all the insects that infest stored grain; Bt products are effective against Indianmeal moth larvae. Dichlorvos resin strips may be hung in the bin headspace as a further deterrent to Indianmeal moth infestation. See the text starting in the next column regarding Diacon II and diatomaceous earth.

Long-term storage programs usually allow "rotating" corn in storage—shipping out old corn and replacing it with the new crop each year. Annual rotation of stored corn helps avoid buildup of insect infestations. Where annual rotation is practiced, topdress treatments of *Bt* (for Indianmeal moth) or Actellic applied in April or May usually provide adequate control without treating the entire grain mass.

Soybean

Only the Indianmeal moth infests soybean stored at moisture levels that prevent mold growth. To protect against Indianmeal moth infestation, rake in surface applications of *Bt* or diatomaceous earth after the bin is filled and leveled or by May of the following year. Dichlorvos resin strips may be hung in the bin headspace as a further deterrent to Indianmeal moth infestation. *No other protectant insecticides are registered for application to stored soybean.*

Wheat

Wheat is especially vulnerable to insect infestation because it is harvested in midsummer when stored-product insects are active within and outside storage facilities. Warm temperatures in summer-harvested wheat also contribute to the rapid development and reproduction of insects within bins. Apply Storcide II at the loading auger to all wheat that is to be stored for 1 month or more.

Sorghum

For storage periods of 1 year or longer, apply Actellic or Storcide II at the loading auger, but not before high-temperature drying. Actellic should persist for 12 months or more on sorghum at 12 to 13 percent moisture. Use dichlorvos resin strips or rake in surface applications of *Bt* or diatomaceous earth after the bin is filled and leveled or by May to control Indianmeal moth if the grain mass is not otherwise treated. Topdress applications of Actellic usually will provide adequate protection for one summer's storage if application is made by April or May.

Insecticide Resistance in Stored Grain

Insecticide resistance is an important worldwide problem that is especially common (on an international scale) in stored-product insects. In Illinois, resistance to malathion is widespread among Indianmeal moth populations. Some Illinois populations of the red flour beetle are resistant to malathion, but the range and intensity of this resistance problem are not well known. Populations of the hairy fungus beetle may be resistant to both Actellic and malathion; the geographical range of resistant populations of this species is not known.

Diacon II and Diatomaceous Earth

Diacon II contains the insect-growth regulator methoprene. It prevents the normal growth and maturation of immature insects, killing them before they become adults. It does not kill adult insects and, therefore, may not be as effective as needed in many circumstances.

Table 1. Insecticides registered for use to protect stored grain

Grains treated with protectant insecticides at labeled rates may be fed to livestock or processed for feed or food uses with no waiting period.

Insecticide	Registered for use on	Rate (per 1,000 bu)	Restrictions, comments
Bacillus thuringiensis (many trade names)	Barley, corn, oats, rye, sorghum, soybean, sunflower, wheat	Rate depends upon the product formulation and concentration. Follow label directions for the product in use.	These products control only the larval stage of Indianmeal moths; they must be ingested by the larvae. Apply to the top 4 to 6 inches of grain as it is augered into the bin or incorporate by raking after the bin is filled.
Deltamethrin plus chlorpyrifos-methyl (Storcide II)	Barley, oats, rice, sorghum, wheat	6.6 to 12.4 fl oz in 5 gallons of water per 1,000 bu. See product label for rates for individual commodities.	Controls weevils, lesser grain borer, secondary beetles, and Indiannmeal moth. Dry grain to 12 to 13% moisture for residues to remain effective for 1 year or longer.
Methoprene (Diacon II)	Barley, corn, oats, wheat, sorghum	Apply 0.8 to 7.7 fl oz of formulated product in 5 gallons of water per 1,000 bu. See product label for a tabular listing of dilutions.	Do not apply to soybean. Methoprene prevents growth and development of immature insects but will not kill adults.
Diatomaceous earth (several trade names)	Barley, corn, oats, rye, sorghum, wheat	Rate depends upon the product formulation and concentration. Follow label directions for the product in use.	See text.
Dichlorvos resin strips (DDVP, Vapona)	Barley, corn, oats, rye, sorghum, soybean, sunflower, wheat	Hang one strip per 1,000 cu ft of bin headspace.	Dichlorvos strips release a vapor that kills adult Indianmeal moths before they reproduce and lay eggs.
Pirimiphos-methyl (Actellic 5E)	Corn (including popcorn), sorghum	Apply 8.6 to 11.5 fl oz of Actellic in 5 gallons of water per 1,000 bu. Protects grain for up to 12 months at an application rate of 8.6 oz, and up to 18 months at the 11.5-oz rate. Apply 3 fl oz of Actellic in 2 gallons of water per 1,000 sq ft of surface area as a cap-off treatment *if the entire grain mass is not treated*. Apply half of the mixture to the grain surface and rake into the top 4 inches; then apply the other half to the raked surface.	Do not apply to barley, oats, soybean, or wheat. Do not apply before high-temperature drying. Controls weevils, secondary beetles, and Indianmeal moth. Dry grain to 14 to 15% moisture for pirimiphos-methyl to persist for 1 year or longer. Cap-off treatments do not provide control of insects active beneath the treated layer.

Table 1. Insecticides registered for use to protect stored grain (cont.)

Insecticide	Registered for use on	Rate (per 1,000 bu)	Restrictions, comments
Pyrethrins plus piperonyl butoxide	Barley, corn, oats, rye, sorghum, sunflower, wheat	Rate depends upon the product concentration. Follow label directions of the product in use.	Do not apply to soybean. Short-term residual activity. Useful mainly as a surface spray or aerosol to control larval and adult Indianmeal moths, as well as other pests at the grain surface.

Diatomaceous earth is an abrasive and slightly sorptive dust that damages an insect's body covering and causes death by dehydration. Incorporating surface treatments should provide some control of insects active in the treated layer.

Problems associated with the use of diatomaceous earth as a grain protectant throughout a grain mass include increased wear to grain-moving equipment, the generation of great amounts of airborne dust during grain handling, and possible reductions in test weight. In addition, diatomaceous earth is not very effective when the grain is wet.

Grain that is identified as having been treated with diatomaceous earth is not downgraded when inspected by official grain graders, but some buyers refuse to accept grain treated with diatomaceous earth if the appearance of the grain is altered by a dusty coating. Conversely, buyers of organic foods or feeds accept grains treated with diatomaceous earth or *Bacillus thuringiensis*, but not grains treated with synthetic chemical insecticides. Due to its cost and the drawbacks discussed, using diatomaceous earth to treat an entire grain mass by admixture at the auger, conveyor belt, or bucket elevator is not advised except in unique circumstances, such as the long-term storage of organically certified grains. For topdress applications, diatomaceous earth gives satisfactory results. Another successful and practical use of diatomaceous earth has been its addition to small seed packets to prevent infestation by stored-product pests.

Sampling Stored Grain

Stored grain should be monitored regularly to determine grain moisture content and temperature and to detect insect infestations. Sample stored grain for insects at least monthly from November through April and at least twice monthly from May through October. Measurements of grain temperature and moisture should be taken twice monthly all year-round. Pay particular attention to the grain surface and the central core of the grain mass, but also sample additional locations and depths. Examine grain from any locations where temperature or moisture readings are substantially higher than average. Deep-bin probes and sectioned grain triers are most commonly used for withdrawing samples from beneath the grain surface. Probe traps and sticky pheromone traps also are available for monitoring insects within the grain mass and flying moths, respectively. Sampling equipment is available from most bin sales and service companies.

Controlling Established Infestations

When insects are found in stored grain, a logical question is: Are there enough insects present to warrant control? The importance of an insect infestation is determined not only by insect numbers but also by type of grain, insect species, time of year, grain temperature and moisture, the planned duration of storage, market potential, and local elevator quality and dockage guidelines. Revised (1988) Federal Grain Inspection Service (FGIS) standards for grain insect infestation are presented in Table 2, but local elevators may enforce more stringent standards. Insect-damaged kernels also may result in price discounts.

Table 2. Number of live insects (per kilogram of grain) required for FGIS designation as "infested"

Crop	Insect number (per kilogram) for designation as "infested"
Wheat, rye, triticale	2 or more live insects that are injurious to stored grain
Barley, corn, oats, sorghum, soybean	More than 1 live weevil *or*
	1 live weevil plus 5 or more other live injurious pest insects *or*
	No live weevils, but 10 or more other live pest insects injurious to stored grain

Options

When insects are detected in stored grain, consider several possible management practices. Sometimes the most profitable action is to clean and sell the grain immediately without any chemical treatment. Immediate sale is appropriate if early stages of insect infestations are detected before insect numbers reach a buyer's detection or discount level. During cool weather, aerating to cool the grain below 50°F prevents insect activity and allows an extended period of safe storage.

Sometimes insect problems are limited primarily to the surface or central core of stored grain. If Indianmeal moth is the only problem, light infestations can be controlled by using *Bt*, Actellic, Reldan, Storcide II, or diatomaceous earth as outlined in Table 1. Unincorporated applications of these insecticides will not control Indianmeal moth larvae already present a few inches below the grain surface. Where abundant webbing indicates a severe infestation, webbing should be raked from the surface before treating; fumigation may be necessary in these situations. If secondary beetles are confined primarily to a central core of fine material, removing one or two loads of grain to extract that core may allow safe storage of the remaining grain.

Infested grain that cannot be treated successfully in any other way should be fumigated. Safety concerns and protective equipment requirements for fumigants suggest that fumigating farm-stored grain is potentially dangerous and difficult. Hiring a professional fumigator is strongly recommended, especially for the fumigation of bins with capacities greater than 5,000 bushels. Farmers who wish to fumigate their own grain must pass a specific Private Applicator Grain Fumigation Exam. Training materials for that exam cover the products and procedures used for farm bin fumigation.

For those who hire a professional fumigator, the fumigants that may be used in stored grain include methyl bromide, phosphine (from aluminum phosphide or magnesium phosphide pellets or tablets that release phosphine gas), and sulfuryl fluoride. A combination of phosphine and sulfuryl fluoride (Profume) also may be used. Additionally, carbon dioxide, alone or in combination with nitrogen or with phosphine (ECO_2Fume), can be used effectively in bins that are very well sealed. Sealing the seams of bolted farm bins is necessary to reduce CO_2 leaks and make the process cost-effective.

Beneficial Insects

One or more companies market programs that call for periodic releases of beneficial insects (predators and parasitoids of pest species) for pest management in stored grains. Although considerable research has been directed at this practice, questions remain unanswered concerning the ability of releases of beneficial insects to lower pest populations to levels required by current grading standards. Published studies conducted in on-farm storage sites have not achieved adequate levels of control.

Where management efforts must be limited to "nonchemical" methods of control, sound cultural practices (sanitation, adequate drying, cleaning, aeration, and annual rotation of the commodity) outperform the release of beneficial insects.

Special Considerations for Stored Seeds

Seed corn in bulk storage (in cribs, bins, and granaries) can be protected from insect damage by using the storage practices and protectant insecticides discussed previously. These practices include proper sanitation, drying, cleaning, and temperature management (aeration), and the use of protectant insecticides such as pirimiphos-methyl (Actellic or Nu-Gro Insecticide S.P.), *Bt*, and pyrethrins plus piperonyl butoxide. Where fumigation of bulk-stored seed corn is necessary, aluminum phosphide fumigants or carbon dioxide can be used effectively without affecting seed germination.

In bagged seed corn (usually not treated with any insecticide), several stored-grain insects may be a problem, but the Indianmeal moth is the most common. Although bulk seed treatments with Actellic,

Bt, or Nu-Gro provide residual control of Indianmeal moth larvae, such treatments must be applied before or during bagging. Small quantities of valuable seed can be protected by cool storage or by adding diatomaceous earth to seed packets. To limit infestations of insects in untreated, bagged seed corn, warehouses may be fogged periodically during the summer with pyrethrins plus piperonyl butoxide. Using proper warehouse sanitation methods, maintaining cool temperatures, and excluding pests (by using screens, tight-fitting doors and windows, caulking, and so forth) also are important. Bagged seed can be fumigated effectively with aluminum phosphide fumigants. Hiring a professional fumigator is advised.

For Further Information

Additional information about pest management in stored grains may be obtained from the following sources:

Picture Sheet X798.01, Stored Grain Insects and Molds. Available from ACES/ITCS Marketing and Distribution, 1917 S. Wright St., Champaign, IL 61820; (800)345-6087.

Illinois Pesticide Applicator Training Manual 39-4: Seed Treatment. Available from ACES/ITCS.

Illinois Pesticide Applicator Training Manual 39-8: Grain Facility. Available from ACES/ITCS.

Stored Grain Pest Management (SP39-8-CD), self-study CD-ROM. Available from ACES/ITCS.

Stored Product Management. Publ. E-912. Available from the Department of Entomology, Oklahoma State University, 127 Noble Research Center, Stillwater, OK 74078.

For a list of addresses of suppliers of insect traps, other sampling equipment, and insecticide application equipment (for stored grains), write to the Department of Crop Sciences, S-322 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801.

Recommended Web Resources

http://pasture.ecn.purdue.edu/~grainlab/
Postharvest grain quality and stored-product protection. Excellent lists of educational resources, including links to online publications.

http://www.usgmrl.ksu.edu/
Current research in USDA–ARS.

http://www.insectslimited.com/
Commercial fumigation services and supplies, fumigation alternatives, current important issues regarding fumigation and other stored-grain management strategies.

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6

Weed Control for Commercial Vegetable Crops

Weed management requires a multifaceted approach, built upon an understanding of weeds and the crop. Weed management may involve nonchemical methods, chemical methods (herbicides), or a combination of the two. Deciding which methods to use depends on environmental concerns, marketing opportunities, desired management intensity, labor availability, weed pressure, and the crop.

The first step in weed management is to identify the weeds and understand their life cycles. For assistance, consult identification guides, such as *Weeds of the North Central States* [Bulletin 772, University of Illinois Agricultural Experiment Station; available from University of Illinois Extension PubsPlus at https://webstore.aces.uiuc.edu/shopsite/ or from ACES/ITCS Marketing and Distribution, 1917 S. Wright St., Champaign, IL 61820; (800)345-6087]. Weeds may be categorized by life cycles, and management strategies can be developed accordingly. Annual weeds complete their life cycles in 1 year and reproduce solely by seed. Annuals are divided into summer and winter groups depending on when they grow. Primary tillage operations often control winter annuals before a crop is planted in the spring. The most common weeds in vegetable crops are summer annuals (such as barnyardgrass, giant foxtail, common purslane, redroot pigweed, and common lambsquarters). Mechanical and cultural weed-management methods help in suppressing summer annuals. Perennial weeds live for more than 2 years and reproduce by seed or vegetative structures (stolons, rhizomes, corms, bulbs, tubers, or roots). Because perennial weeds are extremely difficult to manage in vegetable crops, it is usually better not to use a field with severe perennial weed problems.

There are three sections in this chapter: nonchemical weed-management strategies, chemical weed-management strategies, and environmental and health hazards of herbicides. Many nonchemical weed-management methods are commonsense farming practices. These practices are of increasing importance due to consumer concerns about pesticide residues, potential environmental contamination from pesticides, and unavailability of many older herbicides.

Nonchemical Weed-Management Strategies

Weed management should start with nonchemical strategies that reduce problems caused by weeds. The aim should be to manage the weed population so that it is below a level that reduces your economic return (the economic threshold). In some instances, the cost of controlling weeds may be more than the economic return obtained from any yield increase. This situation occurs when a few weeds are present or the weeds germinate late in the season. In those instances, the best strategy may be to do nothing. In other situations, weed populations and other considerations may require combining herbicides with nonchemical approaches.

Cultural Practices

You should aim to establish a vigorous crop that competes effectively with weeds. This approach starts with your *land selection.* A general rule is not to plant vegetables on land with a history of heavy weed infestation, especially of perennial weeds.

Crop selection can reduce the effects of weed competition. One criterion in selecting a crop should be the

The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.

Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.

weed problems of the field. Plant the most competitive crops in the most weed-infested fields and the least competitive crops in the cleanest ones. Consider planting heavily infested fields as long-term set-aside acres or as nonrow crops such as alfalfa. Permanent cover should help prevent buildup of annual weeds.

Crop rotation is another practice that can reduce weed problems. The characteristics of the crop, the methods used to grow it, and the herbicides used inadvertently allow certain weeds to escape control. Rotation also affects the weed-management tools at your disposal. Rotating between crops improves growth and the crops' competitiveness. Related vegetables should not be grown in the same location in successive years. Table 1 lists related vegetable crops.

Wild proso millet is an example of a problem weed for which rotation is an important management tactic. Rotating from sweet corn to small grains, early-planted peas, or alfalfa almost completely eliminates wild proso millet. Alfalfa, early-planted peas, and small grains are established before the soil is warm enough for wild proso millet to germinate. Rotating from sweet corn to broadleaf crops allows use of post-emergence grass herbicides to manage wild proso millet.

Once a crop is selected, use *adaptive, vigorous varieties* resistant to diseases. Disease-infested plants cannot effectively compete with weeds.

Narrower row spacings and proper plant densities assure that the crop rapidly closes canopy. A closed canopy shades out later-emerging weeds and prevents germination of weed seeds requiring light. Weeds seldom are a problem once canopy closure occurs. Proper row spacing and plant density also allow row cultivation.

Another cultural method to improve crop competitiveness is to use the *correct planting time.* Crops may be divided into warm- and cool-season plants, depending on the optimal temperature for their growth. The planting date affects the time to emergence and early seedling vigor of the crop, which are important in determining crop competitiveness. Cool-season crops germinate at cooler soil temperatures and thus compete better against early-emerging weeds than do warm-season crops. Table 2 lists crops according to their adaptation to field temperatures. Time plantings so that temperatures are favorable for crop growth.

Adequate fertilization and appropriate insect and disease management are important in assuring a competitive crop. Adequate fertility assures rapid, uniform germination and good crop growth, which enhance the crop's competitive ability. For information on fertility, consult *Midwestern Vegetable Production Guide for Commercial Growers* (Circular 1373-06, University of Illinois Extension; available from PubsPlus or ACES/ITCS Marketing and Distribution). Disease-management information is contained in Chapter 9 ("Plant Disease Management for Commercial Vegetable Crops") of this handbook and insect-management information in Chapter 7 ("Insect Pest Management for Commercial Vegetable Crops"). While poor insect and disease control reduce a crop's competitiveness, inadequate weed control can also cause insect and disease problems.

Mulching can be useful in managing weeds. Mulches may be classified as either natural (straw, leaves, paper, and compost) or synthetic (plastic). Because natural mulches are difficult to apply over large areas, they are best for small, specialized areas. Natural mulches should be spread evenly at least 1½ inches thick over the soil to prevent light penetration. Natural mulch materials must be free of weed seeds and other pest organisms and be heavy enough that they are not easily displaced by wind or water. A major advantage of natural mulches is that they add organic matter to the soil.

Table 1. Botanically related vegetables

Corn	**Cucurbits**	**Onions**
Dent corn	Muskmelon	Garlic
Popcorn	Pumpkin	Onion
Sweet corn	Summer squash	
	Watermelon	**Solanaceous**
Crucifers	Winter squash	Pepper
Brussels sprout		Potato
	Legumes	Tomato
Cabbage	Dry bean	
Cauliflower	Lima bean	**Spinach**
Horseradish	Pea	Beets
Kale	Snap bean	Chard
Radish	Soybean	Spinach
Rutabaga		

Table 2. Classification of vegetable crops according to their adaptive field temperatures

Cool-season		Warm-season	
Hardy*	Semihardy	Tender	Very tender
Asparagus	Carrot	Pepper	Cucumber
Broccoli	Cauliflower	Snap bean	Eggplant
Cabbage	Chinese cabbage	Sweet corn	Lima bean
Horseradish	Lettuce		Muskmelon
Onion	Potato		Okra
Pea			Pumpkin
Spinach			Squash
			Watermelon

*Hardy crops are most tolerant of cool temperatures and frost, while very tender crops are most susceptible to frost and cool temperatures.

Synthetic mulches control weeds within the row, conserve moisture, increase soil temperature, and are easy to apply. Black plastic mulches are the most common and are particularly effective in improving early-season growth of warm-season crops such as tomatoes, muskmelons, watermelons, and peppers. Better early-season growth of these crops improves their competitive ability against weeds. Plastic mulches used in combination with trickle irrigation also improve water-use efficiency.

The biggest disadvantage of plastic mulch is disposal, as many landfills do not accept it. Photodegradable plastic mulches have been developed, but their season-long persistence has been a problem. Also, photodegradable mulches just degrade into smaller pieces of plastic that still contaminate the environment. Biodegradable plastic mulches are not yet widely available.

Mechanical Practices

Mechanical weed management relies on primary and secondary tillage implements such as the rotary hoe and the row cultivator. Mechanical weed management starts with seedbed preparation. Few reduced-till systems have been developed for vegetable crops. Reduced-till suggestions are included in the section on chemical weed-management strategies in this chapter.

Moldboard plowing is usually the first step in mechanically managing weeds. It is particularly useful in controlling emerged annual weeds. An important second step is often *rotary hoeing* for mechanically managing weeds in large-seeded vegetable crops (sweet corn, snap beans, lima beans, and peas). Rotary hoeing needs to be done after the weeds germinate but before they emerge. It does not control large-seeded weeds, such as velvetleaf and shattercane.

Once the crop has emerged or transplants are established, a *row cultivator* may be used to manage emerged weeds. Adjust the cultivator sweeps or teeth to dislodge or cover as many weed seedlings as possible. Seedling weeds can be killed by cultivating 1 to 2 inches deep. The best weed control is obtained with a row cultivator in relatively dry soils by throwing soil into the crop row to cover small weed seedlings. Avoid crop injury from poor cultivation, which reduces crop yields.

In some vegetable crops, such as asparagus, *mowing* can be an effective weed-management tool. Mowing can prevent the production of weed seeds and kill upright weeds, reducing competition. Mowing must be carefully timed to prevent the growth of biennial weeds when reducing competition from upright plants. Timely, repeated mowing also helps deplete the food reserves of perennial weeds.

Mechanical control has many limitations that must be considered when designing weed-management systems. Because mechanical management relies on relatively dry weather, a rainy period may eliminate mechanical management options and lead to severe weed competition. Relying entirely on mechanical practices to manage weeds is difficult on large acreages. Also, several weeds are extremely difficult to manage unless herbicides are combined with nonchemical approaches. The problem weeds include wild proso millet in sweet corn, as well as Canada thistle, hemp dogbane, field bindweed, quackgrass, and johnsongrass. Newly introduced problem weeds often show up in scattered patches along headlands and field borders. These probably are best controlled or eradicated with herbicides before large areas are infested.

Biological Practices

Currently, no system using insects or diseases to control weeds common to vegetable crops exists in the Midwest. Most biological management systems using diseases or insects to control problem weeds have centered on western rangeland areas. One biological system that has potential in the Midwest is the use of cover crops to suppress the development of weeds. These systems are still experimental, and problems have been encountered, including the duration of weed control from cover crops and the spectrum of weeds controlled. Herbicides are often required to kill the cover crop and to manage any emerged weeds. Overall, cover-crop systems tend to control small-seeded annual broadleaf weeds the best. The most promising cover-crop system is winter rye. Winter rye is planted in the late summer or early fall; the rye is killed in the spring with Roundup Ultra Max, and the crop is no-till planted. The system is experimental and should be evaluated in small areas before being used extensively.

Table 3 summarizes some of the nonchemical weed-management practices. An integrated approach should be used that combines many different practices to manage weeds. This approach must be adaptive, aiming to prevent weed problems or cope with any that occur.

Chemical Weed-Management Strategies

Several herbicides are often labeled for a crop. Scouting your area to determine which weeds are present can allow you to select the herbicide that can give you the best control. Potential environmental hazards

Table 3. Nonchemical weed-management practices

Practice	Comments
Cultural	
1. Land selection	Avoid fields with a history of weed problems.
2. Crop selection	Grow the most competitive crops in fields with a history of weed problems.
3. Crop rotation	Rotate between vegetables and nonrow crops such as alfalfa. Rotate between vegetables in different botanical categories.
4. Adapted crop varieties	Select crop varieties adapted for your area.
5. Proper row spacings and plant densities	Use row spacings and plant densities that assure rapid crop-canopy closure.
6. Correct planting times	Plant crops when soil temperatures favor rapid germination and emergence.
7. Appropriate fertility, disease, and insect management	Vigorous, healthy crops are more competitive against weeds.
8. Mulch	Natural mulches are difficult to use over large acreages. Synthetic (plastic) mulches are useful to manage weeds within the row in warm-season crops. Consider disposal problems when using plastic mulches.
Mechanical	
1. Moldboard plowing	Can eliminate emerged annual weeds.
2. Rotary hoeing	Useful to manage small-seeded weeds in large-seeded crops such as sweet corn, snap beans, lima beans, and peas.
3. Row cultivating	Dislodge or cover as many weed seedlings as possible. Avoid damaging crop root systems.
4. Mowing	Mow weeds as soon as flowers appear so no viable weed seed is produced.
Biological	
1. Cover crops	Still experimental. Winter rye system is the most promising and most effective against small-seeded broadleaf weeds.
2. Insect or disease pests of weeds	No current system uses insects or diseases to manage weeds common to vegetables.

must be considered when selecting an herbicide. Herbicide labels contain information on these hazards. The last section of this chapter discusses potential environmental hazards.

All the herbicides labeled for a crop are not necessarily listed in Table 4. If you are unfamiliar with an herbicide, conduct a small test under your environmental conditions and cultural practices before using the herbicide extensively.

Always Read and Understand the Herbicide Label Before Use

Reading the herbicide label is a very profitable use of your time. Label information directs you to correct uses, application methods, rates, and potential environmental hazards. Follow label directions for the best possible control with minimal crop injury and environmental contamination. The label contains restrictions on use and discusses environmental and soil conditions that can affect crop injury, influence the effectiveness of weed control, and cause nontarget site effects.

Use an Herbicide That Is Labeled for Your Particular Use and Crop

Using a nonregistered pesticide can cause harmful residues in the vegetable crop, which can result in crop seizure and consumer injury. The label also states whether the herbicide is a restricted use or general use pesticide. Labels for restricted use pesticides contain a statement that the products are restricted and that only licensed applicators may buy them and supervise their application.

The information in this chapter is current as of the date of publication. Watch for notices of changes in the U.S. Environmental Protection Agency (USEPA) registration of herbicides in the *Pest Management and Crop Development Bulletin* (available from University of Illinois Extension Newsletter Service, 528 Bevier Hall, 905 S. Goodwin Ave., Urbana, IL 61801, (800)348-6087; also available free on the Web at http://www.ipm.uiuc.edu/bulletin/index.php). Mail subscriptions are $52. Or look for notices in the *Illinois Fruit and Vegetable News* (available from Rick Weinzierl, Department of Crop Sciences, AW-101 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801).

Reduced-Tillage Systems

Reduced-tillage systems are a method to combat soil erosion. Roundup Ultra Max, Gramoxone Inteon, or Touchdown may be applied outside the normal growing season to control emerged weeds in reduced-tillage systems. Weeds should be growing actively, and the application must be made before the crop has emerged. If you are applying Roundup Ultra Max to control perennial weeds, it is recommended that it be applied before disturbing the soil. After Roundup Ultra Max is applied, it must be allowed to translocate throughout the perennial weed for several days, or incomplete control may result. Follow Roundup Ultra Max label directions carefully for the rates and timing of application. If perennial weeds are not a major problem, you can eliminate early flushes of weeds by applying Roundup Ultra Max or Gramoxone Inteon to all weeds that emerge. Plant the crop with minimal working of the soil. Never apply Roundup Ultra Max or Gramoxone Inteon to an emerged crop because severe crop injury or death will occur.

Roundup Ultra Max and Gramoxone Inteon control most annual broadleaf and grass weeds. Neither herbicide has any soil-residual activity, so other weed-control measures are necessary during the growing season. Gramoxone Inteon also suppresses perennials by killing their shoots but should not be expected to control regrowth of perennial weeds from rhizomes or other underground storage organs. Roundup Ultra Max is better for controlling perennials because it kills shoots and translocates to destroy underground parts. Roundup Ultra Max only suppresses some particularly hard-to-control perennials, such as bindweed, hemp dogbane, and milkweed. To obtain control of these perennials, applications of high rates, repeat applications of Roundup Ultra Max (within label guidelines), or mechanical removal may be necessary.

How to Use Herbicide Tables

Use Table 4 to determine the herbicides that are labeled for use in your crop. Once you have determined the herbicides available for your crop, use Table 5 to determine which of the labeled herbicides provides control of the weeds you have present. If you are uncertain of the herbicide name, you can find both common and trade names of all herbicides in this chapter in Table 6. These tables are not intended to replace careful reading of a current herbicide label. **Always read the label before applying any pesticide.**

Herbicide Rates and Guidelines for Use in Vegetable Crops

All herbicide rates given in Table 4 are in rate of product per broadcast acre. Adjust amounts accordingly for banded applications. Make preemergence applications before weeds emerge or after removing any weeds present. Make postemergence applications after weeds have emerged. Make stale-seedbed treatments only if weeds have emerged but no crop plants are present.

(Text continues on page 189.)

Table 4. Herbicide rates and guidelines for use in vegetable crops

Herbicide	Rate of product per broadcast acre	Remarks
ASPARAGUS		
Preemergence		
Devrinol (napropamide)	4 to 8 lb of 50DF	Rainfall or irrigation is necessary for activity. Established beds only.
Karmex, others (diuron)	2 to 4 lb of 80DF	Do not apply to young plants during the first year. Two applications per year may be made. See label restrictions.
Lorox (linuron)	2 to 4 lb of 50DF	
Sencor (metribuzin)	1 to 2 qt of 4L or 4F	Established beds only.
Sinbar (terbacil)	1.5 to 3 lb of 80WP	With direct-seeded asparagus, spray activated carbon over rows. High-organic soils inactivate Sinbar. Do not use on soils with less than 1% organic matter.
Spartan (sulfentrazone)	6.7 oz of 75DF	Apply to establish crop in spring prior to spear emergence. Rainfall or irrigation needed to move into soil. Maximum one application per year.
Solicam (norflurazon)	2.5 to 5 lb of 80DF	Apply in the fall after chopping ferns or in the spring before emergence. One application per year.
Treflan, others (trifluralin)	1 to 4 pt of HFP	See label for incorporation instructions. Established beds only.
Postemergence		
2,4-D amine	See label.	Apply to actively growing weeds.
Clarity, Banvel (dicamba)	0.5 to 1 pt	Apply to actively growing weeds immediately after harvest. Discard crooked spears. May cause injury to susceptible plants.
Fusilade DX (fluazifop-butyl)	2 to 3 pt	Use oil concentrate or nonionic surfactant. Apply to nonbearing asparagus only.
Lorox (linuron)	1 to 3 lb of 50DF	Make one to three applictions before weeds exceed 4 inches in height. Apply before cutting season or immediately after cutting.
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use a crop-oil concentrate.
Sandea (halosulfuron)	0.5 to 1.5 oz/A	Apply to established asparagus bed or 6 weeks after transplanting. Make a maximum of two applications per crop cycle.
Stringer (clopyralid)	⅓ to ⅔ pt of 3EC	Do not use on harvested spears.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
ASPARAGUS (CONT.)		
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	See discussion of reduced-tillage systems.
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems. Apply at least 1 week before spears emerge or delay until after harvest.
CARROTS		
Preemergence		
Treflan, others (trifluralin)	1 to 2 pt of HFP	Must be incorporated.
Postemergence		
Fusilade DX (fluazifop-butyl)	2 to 3 pt	Use crop-oil concentrate or nonionic surfactant. Two applications per year may be made.
Lorox (linuron)	1 to 2 lb	Apply when crop is at least 3 inches tall. Do not use if temperature is above 85°F.
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate.
Sencor (metribuzin)	0.33 lb of 75DF or 0.5 pt of 4L	See label warnings. Carrots must have at least 5 or 6 leaves. Weeds must be small.
Select (clethodim)	0.5 pt	Use crop-oil concentrate.
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	See discussion of reduced-tillage systems.
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
COLE CROPS (BROCCOLI, BRUSSELS SPROUT, CABBAGE, CAULIFLOWER, AND TURNIP)		
Preemergence		
Command (clomazone)	0.7 to 1.3 pt of 3ME	Cabbage only. Apply before transplanting. May cause early-season stunting or discoloration of cabbage.
Dacthal (DCPA)	6 to 14 pt of F	Activity is improved by shallow incorporation or irrigation after application.
Devrinol (napropamide)	2 to 4 lb of 50DF	May apply to transplants or direct-seeded plants. Incorporate shallowly.
Goal (oxyfluorfen)	1 to 2 pt of 2XL	Apply to soil after final tillage but before transplanting. May cause foliar injury. Do not apply to Brussels sprout.
Prefar (bensulide)	5 to 6 qt of 4EC	Incorporate shallowly.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
COLE CROPS (BROCCOLI, BRUSSELS SPROUT, CABBAGE, CAULIFLOWER, AND TURNIP) (CONT.)		
Preemergence (cont.)		
Spartan (sulfentrazone)	2.25 to 12 oz	Processing cabbage only, transplanted or direct-seeded cabbage only.
Treflan, others (trifluralin)	1 to 1.5 pt (direct-seeded) or 1 to 2 pt (transplanted) of HFP	Direct-seeded cole crops exhibit marginal tolerance to Treflan. Stunting can occur under stress. Must be incorporated.
Postemergence		
Aim (carfentrazone)	2 fl oz	Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant.
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. Maximum of 3 pt Poast per acre per season. 30-day preharvest interval.
Stinger (clopyralid)	4 to 8 fl oz	Emerged broadleaves, primarily composites; 2 applications maximum per year. 30-day preharvest interval.
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	See discussion of reduced-tillage systems.
Roundup Ultra Max, Touchdown, others (glyphosate)	2 to 3 qt	See discussion of reduced-tillage systems.
CORN (POP)		
Preemergence		
AAtrex, others (atrazine)	3.2 to 4 pt of 4L or 1.8 to 2.2 lb of Nine-O	Restricted use pesticide. Weed resistance to atrazine is a problem. Atrazine can contaminate surface water and groundwater. Atrazine carryover can injure follow crops.
Balance Pro (isoxaflutole)	1.25 to 3 oz of WDG or 1.5 to 4.5 fl oz of SC	
Callistro (mesotrione)	6 to 7.7 fl oz	Use with a grass-active herbicide. Yellow popcorn only. Do not use with soil-applied organophosphate or carbamate insecticide.
Dual Magnum, others (*S*-metolachlor)	1 to 2 pt of 7.6EC	
Eradicane (EPTC + safener)	4.75 to 7.33 pt of 6.7EC	Must be incorporated. Can help with perennial grass control; see label.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
CORN (POP) (CONT.)		
Preemergence (cont.)		
Harness, Degree, DoublePlay, TopNotch (acetolachlor)	1.25 to 2.75 pt of Harness 7EC, 2.75 to 5.5 pt of Degree 3.8ME, or 4.5 to 7 pt of DoublePlay, or 4 to 6 pt of TopNotch	
Lasso, others (alachlor)	2 to 4 qt of 4EC	
Outlook (dimethenamid-P)	12 to 21 fl oz of 6EC	
Prowl H_2O, others (pendimethalin)	2 to 4 pt of H_2O	Popcorn seed must be more than 1.5 in. deep. Do not use in minimum or no-till.
Sutan+ (butylate + safener)	2.5 to 3.5 qt of 6.7EC	Especially useful on sandy soils. Must be incorporated.
Postemergence		
2,4-D amine (numerous trade names)	See label.	Apply to actively growing broadleaf weeds, preferably before corn is 8 inches tall, or use drop nozzles. Do not treat corn in the tassel to dough stage. May cause stalk to become brittle.
AAtrex, others (atrazine)	1 to 1.5 pt of 4L or 1.6 lb of Nine-O	Applied with crop oils. See label precautions. Do not use after June 10.
Accent (nicosulfuron)	0.66 oz of 75DF	Avoid using with some soil insecticides, such as Counter. Check with popcorn company to determine variety tolerance. Do not apply to popcorn taller than 20 inches (6 or fewer collars).
Aim (carfentrazone)	0.33 oz of 40WG	Use in a tank mix with other post herbicides.
Banvel and Clarity (dicamba)	0.5 to 1 pt of Banvel or 16 fl oz of Clarity	**Can injure sensitive crops.** Verify that popcorn variety is tolerant before using. Apply to popcorn between emergence and 8 inches tall (5-leaf stage).
Basagran (bentazon)	1.5 to 2 pt of 4S	Apply when weeds are small and actively growing. Use crop-oil concentrate.
Beacon (primisulfuron)	0.76 oz of 74WD	Only make semidirected or directed applications with drop nozzles when popcorn is between 10 and 48 inches tall and before tassel emergence. Test varieties for sensitivity to Beacon before using.
Buctril (bromoxynil)	1 to 1.5 pt of 2EC	Primarily a contact herbicide, so thorough coverage is essential for control. Can cause temporary leaf burn of popcorn.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
CORN (POP) (CONT.)		
Postemergence (cont.)		
Callisto (mesotrione)	3 oz	Yellow popcorn only. Use crop-oil concentrate only. Add atrazine.
Distinct (diflufenzopyr + dicamba)	4 to 6 oz	Do not apply to corn more than 36 inches tall. Use nonionic surfactant plus UAN.
Impact (topramezone)	0.75 fl oz	Popcorn varieties vary in tolerance. Mix with atrazine. Use a crop-oil concentrate.
Resource (flumiclorac)	4 to 8 fl oz	Do not apply under stress conditions.
Sandea (halosulfuron)	0.67 to 1 oz of 75WSG	Apply as broadcast or directed spray from spike to layby. Include 0.5% nonionic surfactant. Controls nutsedge.
Stringer (clopyralid)	⅓ to ⅔ pt	Do not apply to popcorn over 24 inches tall. Can make two applications 21 days apart.
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	Restricted use pesticide. See discussion of reduced-tillage systems. Can also be used as a harvest aid.
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 2 pt	See discussion of reduced-tillage systems.
CORN (SWEET)		
Preemergence		
AAtrex, others (atrazine)	3.2 to 4 pt of 4L or 1.8 to 2.2 lb of Nine-O	Restricted use pesticide. Can contaminate surface water and groundwater. Weed resistance is a problem. Can injure follow crops.
Callisto (mesotrione)	3 to 7.7 fl oz	Use with a grass-active herbicide. Follow rotation restrictions. Do not use with soil-applied organophosphate or carbamate insecticide.
Dual Magnum (*S*-metolachlor) or Dual Magnum II	1 to 2 pt of 7.6EC	May be incorporated or applied before emergence.
Eradicane Extra (EPTC + safener + extender)	4 to 8 pt of 6.7EC	Suppresses wild proso millet. Must be incorporated. Contains an extender that may lengthen the period of control.
Lasso, others (alachlor)	2 to 4 qt of 4EC	Restricted use pesticide.
Outlook (dimethenamid)	12 to 21 fl oz of 6EC	
Prowl (pendimethalin)	1.2 to 3.6 pt of 3.3EC	Do not incorporate. For use on processing varieties. Do not apply prior to planting.
Surpass, TopNotch (acetochlor)	2 to 3 pt of Surpass or 2 to 3 qt of Topnotch	Restricted use pesticide. Apply as close as possible to planting but before corn emerges.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
CORN (SWEET) (CONT.)		
Preemergence (cont.)		
Sutan+ (butylate + safener)	2.5 to 3.5 qt of 6.7EC	Especially useful on sandy soils. Must be incorporated.
Postemergence		
2,4-D amine	See label.	Apply to actively growing weeds, preferably before corn is 6 inches tall. See label restrictions. Sweet corn injury may occur.
AAtrex, others (atrazine)	1 to 1.5 pt of 4L, or 1.8 lb of 80WP, or 1.6 lb of Nine-O	May be applied with crop oils. See label precautions. Do not use after June 10.
Accent (nicosulfuron)	0.67 oz of 75SP	Processing corn only. Use only on tolerant varieties listed on label.
Aim (carfentrazone-ethyl)	1.9EW at 0.5 fl oz or 40DG at 0.33 oz	To reduce injury, use drop nozzle or direct sprayers.
Basagran 4S (bentazon)	1.5 to 2 pt	Apply when weeds are small and actively growing. Consult label for specific directions.
Callisto (mesotrione)	3 to 7.7 oz	Do not apply 7 days before or after an organophosphate or carbamate insecticide. Do not apply to weeds under stress.
Impact (topramezone)	0.75 fl oz	Sweet corn varieties vary in tolerance. Mix with atrazine. Use a crop-oil concentrate.
Sandea (halosulfuron)	0.67 to 1 oz	Apply from spike to layby. Do not use on stressed corn or on Jubilee. Some varieties may be severely injured. Do not use on corn treated with soil-applied organophosphate insectides.
Starane (fluroxypyr)	11 fl oz	Apply as broadcast up to 4 collars. Treat corn more than 4 collars as directed spray with drop nozzles. Some sweet corn hybrids may be injured.
Stringer (clopyralid)	⅓ to ⅔ pt	Do not apply to sweet corn taller than 18 inches.
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	See discussion of reduced-tillage systems.
Roundup Ultra Max,Touchdown, others (glyphosate)	1.5 to 2 pt	See discussion of reduced-tillage systems.
CUCURBITS (CUCUMBER, MUSKMELON, AND WATERMELON)		
Preemergence		
Alanap (naptalam)	6 to 8 qt of 2L	A second application may be made before vining. Usually tank-mixed with Prefar.
Command (clomazone)	0.4 to 2 pt of 3ME	Do not use on jack-o-lantern pumpkins.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
CUCURBITS (CUCUMBER, MUSKMELON, AND WATERMELON) (CONT.)		
Preemergence (cont.)		
Curbit (ethalfluralin)	3 to 4.5 pt of 3EC	Read label carefully before using. Avoid using on cool, wet soils. Requires signing a waiver of liability before using. Can apply Strategy (a clomazone and ethalfluralin combination).
Prefar (bensulide)	5 to 6 qt of 4EC	Incorporate or irrigate in. May be tank-mixed with Alanap. Do not plant other than label-specified crops for 18 months after application.
Sandea (halosulfuron)	0.5 to 1 oz	Apply after seeding but before cracking. Apply before transplanting.
Sinbar (terbacil)	2 to 4 oz	**Watermelons only.** Not recommended on soils with less than 1% organic matter. Can be applied under plastic mulch.
Treflan, others (trifluralin)	1 to 2 pt of HFP	Apply after establishment to melons that have 3 to 4 true leaves. Direct between rows and incorporate.
Postemergence		
Aim (carfentrazone)	2 fl oz	Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant.
Poast (sethoxydim)	1.0 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. Maximum of 3 pt Poast per acre per season. 14-day preharvest interval.
Sandea (halosulfuron)	0.5 to 1 oz	Some injury might occur.
Select (clethodim)	0.5 pt of 2EC	Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate.
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	See discussion of reduced-tillage systems.
Roundup Ultra Max, Touchdown, others (glyphosate)	0.8 to 8 pt	See discussion of reduced-tillage systems.
DRY BEANS (WHITE, NAVY, KIDNEY, PINTO, LIMA, AND ADZUKI)		
Preemergence		
Dual Magnum (*S*-metolachlor) or Dual II Magnum	1 to 2 pt of 7.6EC	
Eptam (EPTC)	2.5 to 3.5 pt of 7EC	Do not use on adzuki beans, cowpeas, lima beans, or other flat-pod beans. Incorporate immediately.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
DRY BEANS (WHITE, NAVY, KIDNEY, PINTO, LIMA, AND ADZUKI) (CONT.)		
Preemergence (cont.)		
Lasso, others (alachlor)	2.5 to 3 qt of 4EC or MT	Use on lima and red kidney beans only.
Outlook (dimethenamid-P)	10 to 21 fl oz	Apply ppi, pre, or after planting when beans have 1 to 3 trifoliate leaves. Do not use on lima beans.
Prowl (pendimethalin)	1.2 to 3.6 pt of 3.3EC	Must be incorporated.
Pursuit (imazethapyr)	3 fl oz of 2EC	Use on lima and red kidney beans only.
Sandea (halosulfuron)	½ to ⅔ oz	Apply after seeding but prior to cracking.
Treflan, others (trifluralin)	1 to 2 pt of HFP	Must be incorporated.
Postemergence		
Aim (carfentrazone)	2 fl oz	Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant.
Assure II (quizalofop)	6 to 10 fl oz of 0.88EC	Use crop-oil concentrate, 1 qt per acre. Good on quackgrass. 30-day preharvest interval.
Basagran (bentazon)	1 to 2 pt of 4S	Apply when weeds are small. Beans are tolerant after the first trifoliate leaf has expanded. Avoid applying when day temperatures are below 75°F.
Poast 1.5E (sethoxydim)	1 to 2 pt	Use crop-oil concentrate, 2 pt per acre. Maximum of 4 pt Poast per acre per season. 30-day preharvest interval.
Pursuit (imazethapyr)	3 oz of 2 L or 1.08 oz of DG	Apply after first trifoliate. Add an adjuvant.
Raptor (imazamox)	4 oz	Apply when beans are in first- to third-trifoliate leaf stage. Weeds must be actively growing. Include nonionic surfactant. **Fresh lima beans:** Tank-mix with Basagran to minimize lima bean response. Apply when lima beans are in first- to second-trifoliate leaf stage.
Reflex (fomesafen)	1.25 pt	Use only in alternate years. Apply to beans with > 4 fully expanded trifoliate leaves. Apply with a nonionic surfactant or a crop-oil concentrate. Do not use liquid N.
Sandea (halosulfuron)	0.5 to 0.67 oz	Add ½ to 1 pt nonionic surfactant and not recommended for use under cool temperatures. (Dry bean and lima bean only.)

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
DRY BEANS (WHITE, NAVY, KIDNEY, PINTO, LIMA, AND ADZUKI) (CONT.)		
Postemergence (cont.)		
Select (clethodim)	6 to 8 fl oz	Include a crop-oil concentrate. Apply to actively growing grass.
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	See discussion of reduced-tillage systems. Use on lima beans only. Also can be used as a harvest aid on dry beans.
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
EGGPLANT		
Preemergence		
Dacthal (DCPA)	6 to 14 pt of F	Apply 4 to 6 weeks after transplanting. Shallow incorporation or irrigation improves activity.
Devrinol (napropamide)	2 to 4 lb of 50DF	Transplants only.
Prefar (bensulide)	5 to 6 qt	Apply before planting and incorporate 1 to 2 inches.
Sandea (halosulfuron)	0.5 to 1 oz	Use between row middles. Do not contact planted crop. Keep application off plastic mulch.
Trilin (trifluralin)	1 to 1.5 pt of HFP	Transplants only. Requires signing a liability waiver before using.
Postemergence		
Gramoxone Inteon (paraquat)	2 pt	Direct application between rows after establishment. Do not contact crop, or injury and/or death will occur. Apply when weeds are succulent and growth < 6 inches.
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre.
Select (clethodim)	0.5 pt	Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate.
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	See discussion of reduced-tillage systems.
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
GREENS (CHICORY, COLLARD, KALE, MUSTARD, SPINACH, TURNIP)		
Preemergence		
Dacthal (DCPA)	6 to 14 pt of F	Use on collard greens, kale, mustard greens, and turnip greens. Shallow incorporation or irrigation improves activity.
Prefar (bensulide)	5 to 6 qt of 4EC	Lightly incorporate. Not for turnip greens.
Treflan, others (trifluralin)	1 to 1.5 pt of HFP	Incorporate. Not for turnip greens.
Postemergence		
Aim (carfentrazone)	2 fl oz	Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant.
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. 30-day preharvest interval for all except spinach, which requires a 15-day preharvest interval.
Stringer (clopyralid)	½ pt	Use on spinach, turnip greens, and roots. Do not apply within 15 days (greens) or 30 days (roots) of harvest.
Select (clethodim)	6 to 8 fl oz	Include a crop-oil concentrate. Apply to actively growing grass.
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	Collards only. See discussion of reduced-tillage systems.
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
HORSERADISH		
Preemergence		
Dacthal (DCPA)	6 to 14 pt of F	Shallow incorporation or irrigation improves activity.
Dual Magnum (*S*-metolachlor)	1 to 2 pt	May cause crop injury. 24c label for Illinois only.
Goal (oxyfluorfen)	2 pt of 2XL	Apply after planting and before emergence. Some crop injury may occur.
Outlook (dimethenamid-P)	12 to 21 fl oz	Apply from 2-leaf stage to 8-leaf stage of horseradish. Cold, wet conditions at application may cause horseradish stunting. Will not control emerged weeds.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
HORSERADISH (CONT.)		
Preemergence (cont.)		
Spartan (sulfentrazone)	1.5 to 6.3 oz	Apply after planting. Do not incorporate.
Postemergence		
Aim (carfentrazone)	2 fl oz	Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant.
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre.
Select (clethodim)	0.5 pt	Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate.
Stale seedbed		
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
LETTUCE		
Preemergence		
Balan (benefin)	2 to 2.5 lb of 60DF	Must be incorporated.
Kerb (pronamide)	2 to 4 lb of 50WP	Moisture is necessary to activate. Label rates vary depending on variety.
Prefar (bensulide)	5 to 6 qt of 4EC	May be applied to head and leaf lettuce. Must be incorporated.
Postemergence		
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. Preharvest intervals are 15 days for leaf and 30 days for head lettuce.
Select (clethodim)	6 to 8 fl oz	Include a crop-oil concentrate. Apply to actively growing grass. Leaf lettuce only.
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	See discussion of reduced-tillage systems.
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
OKRA		
Preemergence		
Treflan, others (trifluralin)	1 to 2 pt of HFP	Must be incorporated immediately after application.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
OKRA (CONT.)		
Postemergence		
Aim (carfentrazone)	2 fl oz	Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant.
Stale seedbed		
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
ONION		
Preemergence		
Chateau (flumioxazin)	1 to 2 oz of WDG	Apply to onions with 3 to 6 leaves. Do not tank-mix. Onions should be weed free.
Dacthal (DCPA)	6 to 14 pt of F	Can apply at seeding or transplanting or at layby. Irrigation after application improves activity.
Outlook (dimethenamid-P)	12 to 21 fl oz	Apply after dry bulb onions have reached 2 true leaves. Will not control emerged weeds.
Prefar (bensulide)	5 to 6 qt of 4EC	Dry bulb onions only. Incorporate or irrigate in.
Prowl (pendimethalin)	0.6 to 2.4 qt of 3.3EC	Apply when direct-seeded onions have 2 to 9 leaves or after transplanting.
Postemergence		
Buctril (bromoxynil)	1 to 1.5 pt of 2EC	Apply 2 to 3 days before onions emerge or when they have 2 to 5 true leaves. Sensitivity of onions is affected by variety and environment.
Fusilade DX (fluazifop-P-butyl)	1.25 to 1.5 pt of 1EC	Use nonionic surfactant, 1 pt per acre. 45-day preharvest interval. Use only on dry bulb onions.
Goal (oxyfluorfen)	5 to 10 fl oz of 1.6EC	Do not apply until onions have 2 true leaves. Best control is achieved when weeds are in the 2- to 4-leaf stage. Do not apply more than 2.5 pt per broadcast acre in one season. Use only on dry bulb onions.
Poast (sethoxydim)	1 to 1.5 pt	Add 2 pt crop-oil concentrate per acre. 30-day preharvest interval. May be used on dry bulb onions, green bunching onions, garlic, and leeks.
Select (clethodim)	6 to 16 fl oz	Apply to actively growing grasses. Include 1% crop-oil concentrate.
Stale seedbed		
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
PEAS		
Preemergence		
Command (clomazone)	1 pt of 3ME	
Dual Magnum (*S*-metolachlor)	1 to 2 pt of 7.6EC	Apply preemergence. See label for restrictions.
Prowl (pendimethalin)	1.2 to 3.6 pt	Incorporate.
Pursuit (imazethapyr)	3 fl oz of 2EC	Do not use if applying Treflan to peas.
Treflan, others (trifluralin)	1 to 1.5 pt of HFP	Must be incorporated.
Postemergence		
Aim (carfentrazone)	2 fl oz	Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant.
Assure II (quizalofop)	6 to 12 fl oz of 0.88EC	Use crop-oil concentrate, 2 pt per acre. Good on quackgrass. 30-day preharvest interval.
Basagran (bentazon)	1.5 to 2 pt of 4S	Apply when weeds are small. Pea injury can occur. See label precautions. Do not add crop oil.
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre.
Pursuit (imazethapyr)	3 fl oz of 2EC	Add nonionic surfactant. Crops must have at least 1 true leaf, or crop injury may result. Do not apply if Treflan is used.
Raptor (imazamox)	3 oz	Apply to English peas at least 3 inches in height and before 5 nodes. May injure peas. Do not use if trifluralin applied ppi. If nitrogen fertilizer used, then tank-mix with Basagran to reduce pea injury.
Thistrol (MCPB)	2 to 4 pt of 2EC	Apply when peas have developed 6 to 12 nodes and weeds are less than 3 inches tall. Use for Canada thistle control.
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	See discussion of reduced-tillage systems.
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
PEPPER		
Preemergence		
Command (clomazone)	0.5 to 2 pt of 3ME	Use lower rates on light soil textures. Varieties differ in tolerance. Do not use on banana peppers.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
PEPPER (CONT.)		
Preemergence (cont.)		
Devrinol (napropamide)	2 to 4 lb of 50DF	May be applied to direct-seeded plants or transplants. Incorporate.
Prefar (bensulide)	5 to 6 qt of 4EC	Lightly incorporate.
Treflan, others (trifluralin)	1 to 2 pt of HFP	Incorporate. Apply to transplants only.
Postemergence		
Aim (carfentrazone)	2 fl oz	Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant.
Gramoxone Inteon (paraquat)	2 pt	Direct application between rows after establishment. Do not contact crop, or injury and/or death will occur. Apply when weeds are succulent and growth < 6 inches.
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. Maximum of 4.5 pt Poast per acre per season. 20-day preharvest interval.
Sandea (halosulfuron)	0.5 to 1 oz	Apply between rows. Do not contact crop plants. Do not apply over plastic mulch.
Select (clethodim)	0.5 pt	Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate.
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	See discussion of reduced-tillage systems. Can also be used as a harvest aid.
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
POTATO		
Preemergence		
Dual Magnum (*S*-metolachlor) or Dual II Magnum	1 to 2 pt of 7.6EC	Apply preemerge, incorporated, or at layby. Do not use on muck soils.
Eptam (EPTC)	3.5 to 7 pt of 7EC	Incorporate immediately after applying. The variety Superior is sensitive.
Linex or Lorox (linuron)	1.5 to 2.5 pt of 4L, or 1 to 4 lb of 50WP or 50DF	Apply after planting but before potato emergence. Plant "seed" 2 inches deep.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
POTATO (CONT.)		
Preemergence (cont.)		
Matrix (rimsulfuron)	1 to 1.5 oz of 25DF	Apply after hilling or drag-off, and before potatoes and weeds emerge.
Outlook (dimethenamid-P)	12 to 21 fl oz	Apply following planting or after drag-off. Cold, wet conditions at application may cause potato stunting. Will not control emerged weeds.
Prowl (pendimethalin)	1.2 to 3.6 pt of 3.3EC	Incorporate lightly. Do not use on muck soils.
Sencor (metribuzin)	0.6 to 1.33 lb of 75DF	Make a single application before emergence.
Treflan, others (trifluralin)	1 to 2 pt of HFP	Apply after planting and incorporate uniformly.
Postemergence		
Aim (carfentrazone)	2 fl oz	Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant.
Matrix (rimsulfuron)	1 to 1.5 oz of 25DF	Apply before potatoes are 14 inches tall. Spray only after 3 days of sunny weather. May injure potatoes.
Poast (sethoxydim)	1 to 2.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. Maximum of 5 pt Poast per acre per season. 30-day preharvest interval.
Select (clethodim)	0.5 pt	Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate.
Sencor (metribuzin)	0.5 to 1 pt of 4L, or 0.3 to 0.67 lb of 75DF	Do not use on smooth-skinned white or red-skinned potatoes. Apply only after 3 successive days of sunny weather. Apply before weeds are 1 inch tall.
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	See discussion of reduced-tillage systems. Can also be used as a harvest aid.
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
PUMPKIN AND SQUASH		
Preemergence		
Command (clomazone)	1.5 to 2 pt of 3ME	Processing pumpkins and squash only. Do not use on jack-o-lantern pumpkins.
Curbit (ethalfluralin)	3 to 4.5 pt of 3EC	Apply after seeding squash or pumpkins and before weed or crop emergence. Carefully read label before using. Requires signing a liability waiver.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
PUMPKIN AND SQUASH (CONT.)		
Preemergence (cont.)		
Dual Magnum (*S*-metolachlor)	1 to 1.33 pt	Do not apply once pumpkin emerge. May injure pumpkin. Must obtain label through www.farmassist.com and agree to Syngenta's terms.
Prefar (bensulide)	5 to 6 qt of 4EC	Incorporate or irrigate in. See label restrictions.
Sandea (halosulfuron)	0.5 to 1 oz	Preemergence application is safer than postemergence.
Treflan and others (trifluralin)	1 to 2 pt of 4EC	Apply as directed. Spray between rows after plants have 3 to 4 leaves and incorporate.
Postemergence		
Aim (carfentrazone)	2 fl oz	Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant.
Poast (sethoxydim)	1 to 1.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. Maximum of 3 pt Poast per acre per season. 14-day preharvest interval.
Sandea (halosulfuron)	0.5 to 1 oz	Preemergence application is safer than postemergence.
Select (clethodim)	0.5 pt	Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate.
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	See discussion of reduced-tillage systems.
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
SNAP BEANS OR GREEN BEANS		
Preemergence		
Command (clomazone)	0.4 to 0.67 pt	Surface apply before seeding or after seeding before crop emergence.
Dual Magnum (*S*-metolachlor) or Dual II Magnum	1 to 2 pt of 7.6EC	
Eptam (EPTC)	3.5 pt of 7EC	Do not use on flat-pod beans. Must be incorporated.
Prowl (pendimethalin)	1.2 to 3.6 pt of 3.3EC	Apply before planting and incorporate.
Sandea (halosulfuron)	0.5 to 1 oz	Apply after planting but before cracking.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
SNAP BEANS OR GREEN BEANS (CONT.)		
Preemergence (cont.)		
Treflan, others (trifluralin)	1 to 1.5 pt of HFP	Must be incorporated.
Postemergence		
Aim (carfentrazone)	2 fl oz	Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant.
Assure II (quizalofop)	6 to 10 oz of 0.88EC	Use crop-oil concentrate, 2 pt per acre. Good on quackgrass. 30-day preharvest interval.
Basagran (bentazon)	1.5 to 2 pt of 4S	Apply when weeds are small. Beans are tolerant after the first-trifoliate leaf has fully expanded. Some injury to beans may occur.
Poast (sethoxydim)	1 to 2.5 pt of 1.5EC	Use crop-oil concentrate, 2 pt per acre. Maximum of 4 pt Poast per acre per season. 15-day preharvest interval.
Reflex (fomesafen)	1.25 pt	Use only in alternate years. Apply to beans with at least 1 fully expanded trifoliate leaf. Apply with a nonionic surfactant or a crop-oil concentrate. Do not use liquid N.
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	See discussion of reduced-tillage systems.
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
SWEET POTATO		
Preemergence		
Command (clomazone)	1.3 to 3.3 pt of 3ME	Surface apply before or after transplanting. Use 1.5 pt per acre if applied after transplanting.
Devrinol (napropamide)	2 to 4 lb of 50DF	Apply immediately after transplanting. If no rain within 24 hours, then shallowly incorporate.
Postemergence		
Fusilade (fluzifop-P)	10 to 12 fl oz	Apply to actively growing grasses. Include 1 qt per acre of crop-oil concentrate or 1 pt per acre of nonionic surfactant.
Poast (sethooxydim)	1 to 1.5 pt	Apply to actively growing grasses. Include 1 qt per acre of crop-oil concentrate.
Select (clethodim)	9 to 16 fl oz	Apply to actively growing grasses. Include 0.25% nonionic surfactant.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
SWEET POTATO (CONT.)		
Stale seedbed		
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
TABLE BEETS (RED BEETS)		
Preemergence		
Pyramin (pyrazon)	2.75 to 3.25 qt of 4.5SC, or 4.6 to 5.4 lb of 68DF	Rainfall or irrigation is needed for activation.
Ro-Neet (cycloate)	2 to 3 qt	Apply before planting. Incorporate 2 to 3 inches deep.
Postemergence		
Aim (carfentrazone)	2 fl oz	Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant.
Poast (sethoxydim)	1 to 1.5 pt	Apply to actively growing grasses. Include 1 qt crop-oil concentrate per acre.
Pyramin (pyrazon)	3.5 qt of 4.2FL	Timing is very important. Treat when beets have 2 expanded leaves and weeds have 2 to 4 leaves.
Select (clethodim)	0.5 pt	Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate.
Spin-aid (phenmediphon)	3 to 6 pt of 1.3EC	Apply after beets have 4 leaves.
Stringer (clopyralid)	½ pt	Do not apply within 30 days of harvest.
Stale seedbed		
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.
TOMATO		
Preemergence		
Devrinol (napropamide)	2 to 4 lb of 50DF	Must be incorporated.
Dual Magnum (metolachlor)	1 to 2 pt	Apply preplant before transplanting. Do not apply when cool, wet conditions exist.
Prefar (bensulide)	4 to 5 qt of 4EC	Incorporate or irrigate in. Do not plant other than specified crops for 18 months after treatment.
Sandea (halosulfuron)	½ to 1 oz	Can be applied preplant under plastic mulch. Wait 7 days before planting.
Sencor (metribuzin)	0.5 to 1 pt of 4L, or 0.33 to 0.66 lb of 75DF	Apply to transplanted tomatoes only. May be incorporated.

Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)

Herbicide	Rate of product per broadcast acre	Remarks
TOMATO (CONT.)		
Preemergence (cont.)		
Treflan, others (trifluralin)	1 to 2 pt of HFP	Must be incorporated. For direct-seeded plants, apply at blocking or thinning as a directed spray between rows.
Postemergence		
Aim (carfentrazone)	2 fl oz	Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant.
Gramoxone Inteon (paraquat)	2 pt	Direct application between rows after establishment. Do not contact crop, or injury and/or death will occur. Apply when weeds are succulent and growth < 6 inches.
Matrix (rimsulfuron)	2 oz	Processing tomatoes only. Include 0.25% nonionic surfactant.
Poast (sethoxydim)	1.0 to 1.5 pt	Use crop-oil concentrate, 2 pt per acre. Maximum of 4.5 pt Poast per acre per season. 20-day preharvest interval.
Sandea (halosulfuron)	0.5 to 1 oz	Transplants only. Apply 4 days after transplanting. Can be applied as over-the-top application.
Select (clethodim)	0.5 pt	Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate.
Sencor (metribuzin)	0.5 to 0.75 pt of 4L, or 0.33 to 0.67 lb of 75DF	Plants must be established; see label. Apply only after 3 successive days of sunny weather.
Stale seedbed		
Gramoxone Inteon (paraquat)	2 to 4 pt	See discussion of reduced-tillage systems.
Roundup Ultra Max, Touchdown, others (glyphosate)	1.5 to 3 qt	See discussion of reduced-tillage systems.

Table 5. Weed susceptibility to herbicides labeled for use in vegetable crops

	Weeds controlled	
Herbicide	Grasses	Broadleaves
2,4-D amine		carpetweed, dandelion, dock, galinsoga, jimsonweed, lambsquarters, morningglory, pigweed, plantain, ragweed, smartweed, thistle, wild mustard
Accent (nicosulfuron)	barnyardgrass, fall panicum, foxtail, johnsongrass, quackgrass, sandbur, shattercane, sorghum almum, wild proso millet	burcucumber, jimsonweed, morningglory, pigweed, smartweed
Aim (carfentrazone)		lambsquarters, morningglory, nightshade, pigweed, velvetleaf
Alanap (naptalam)		carpetweed, chickweed, cocklebur, hairy galinsoga, lambsquarters, purslane, ragweed
Assure (quizalofop)	fall panicum, foxtail, johnsongrass, quackgrass, sandbar, shattercane, volunteer grains, wild proso millet, witchgrass	
Balan (benefin)	annual bluegrass, barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, seedling johnsongrass	carpetweed, chickweed, knotweed, lambsquarters, pigweed, purslane
Balance (isoxaflutole)	barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, shattercane, witchgrass	galinsoga, jimsonweed, lambsquarters, morningglory, nightshade, pigweed, purslane, ragweed, smartweed, sunflower, velvetleaf
Banvel, Clarity (dicamba)		cocklebur, dandelion, dock, fleabane, jimsonweed, ladysthumb, lambsquarters, milkweed, morningglory, mustard, nightshade, pigweed, prickly lettuce, ragweed, smartweed, velvetleaf
Basagran (bentazon)		Canada thistle, cocklebur, galinsoga, jimsonweed, lambsquarters, purslane, ragweed, smartweed, velvetleaf, wild mustard
Beacon (primisulfuron)	fall panicum, foxtail, johnsongrass, quackgrass, sandbur, shattercane	burcucumber, cocklebur, horsenettle, horseweed, jimsonweed, kochia, lambsquarters, morningglory, nightshade, pigweed, prickly sida, puncturevine, ragweed, smartweed, sunflower
Buctril (bromoxynil)		annual morningglory, cocklebur, jimsonweed, lambsquarters, mustard, nightshade, pennycress, pigweed, smartweed

Table 5. Weed susceptibility to herbicides labeled for use in vegetable crops (cont.)

	Weeds controlled	
Herbicide	Grasses	Broadleaves
Callisto (mesotrione)	crabgrass	amaranth, cocklebur, horsenettle, jimsonweed, lambsquarters, nightshade, pigweed, ragweed, smartweed
Chateau	barnyardgrass, crabgrass, foxtail, goosegrass, fall panicum	carpetweed, chickweed, henbit, lambsquarters, nightshade, pigweed, prickly sida, purslane, smartweed, spruge, velvetleaf
Command (clomazone)	barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, seedling johnsongrass	jimsonweed, lambsquarters, purslane, ragweed, smartweed, velvetleaf
Curbit (ethalfluralin)	annual bluegrass, barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, seedling johnsongrass, shattercane, witchgrass	carpetweed, chickweed, lambsquarters, nightshade, pigweed, purslane, wild buckwheat
Dacthal (DCPA)	barnyardgrass, crabgrass, foxtail, goosegrass, sandbur	carpetweed, knotweed, lambsquarters, pigweed, purslane
Devrinol (napropamide)	barnyardgrass, crabgrass, foxtail, goosegrass, seedling johnsongrass, weedy brome	chickweed, common groundsel, lambsquarters, pigweed, prickly lettuce, prostrate knotweed, purslane
Distinct (diflufenzopyr + dicamba)		cocklebur, horseweed, ladysthumb, lambsquarters, morningglory, nightshade, pigweed, ragweed, smartweed, thistle, velvetleaf, waterhemp
Dual Magnum (*S*-metolachlor)	barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, witchgrass, yellow nutsedge	carpetweed, galinsoga, nightshade, pigweed
Eptam (EPTC)	annual bluegrass, barnyardgrass, crabgrass, foxtail, goosegrass, shattercane, witchgrass	annual morningglory, carpetweed, chickweed, lambsquarters, nightshade, purslane
Eradicane Extra (EPTC + safener + extender)	annual bluegrass, barnyardgrass, crabgrass, foxtail, goosegrass, seedling johnsongrass, volunteer small grains	annual morningglory, carpetweed, lambsquarters, nightshade, pigweed, purslane, velvetleaf
Fusilade DX (fluazifop-butyl)	barnyardgrass, bermudagrass, crabgrass, fall panicum, foxtail, goosegrass, johnsongrass, volunteer cereals, wild proso millet, witchgrass	
Goal (oxyfluorfen)		black nightshade, common groundsel, evening primrose, pigweed, purslane, shepherd's-purse
Gramoxone Inteon (paraquat)	most annual grasses and broadleaves	See discussion of reduced-tillage systems.

Table 5. Weed susceptibility to herbicides labeled for use in vegetable crops (cont.)

	Weeds controlled	
Herbicide	Grasses	Broadleaves
Harness, others (acetolachlor)	barnyardgrass, crabgrass, cupgrass, foxtail, goosegrass, panicum, sandbur	carpetweed, galinsoga, henbit, lambsquarters, nightshade, pigweed, ragweed
Impact (topramezone)	barnyardgrass, crabgrass, foxtail, goosegrass	amaranth, cocklebur, jimsonweed, lambsquarters, mustard, nightshade, pigweed, prickly sida, ragweed, smartweed, velvetleaf, waterhemp
Karmex, others (diuron)	annual bluegrass, barnyardgrass, crabgrass, foxtail	chickweed, mustard, pennycress, pigweed, purslane, ragweed, velvetleaf
Kerb (pronamide)	annual bluegrass, barnyardgrass, brome, foxtail, goosegrass, panicum, volunteer small grains	carpetweed, chickweed, henbit, knotweed, lambsquarters, morningglory, nightshade, purslane
Lasso, others (alachlor)	barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, witchgrass	carpetweed, galinsoga, nightshade, pigweed, purslane
Linex or Lorox (linuron)	barnyardgrass, crabgrass, fall panicum, goosegrass	annual morningglory, carpetweed, cocklebur, groundsel, lambsquarters, mustard, pigweed, prickly sida, purslane, smartweed, velvetleaf
Matrix (rimsulfuron)	barnyardgrass, foxtail, goosegrass	chickweed, cocklebur, galinsoga, ladysthumb, mustard, pigweed, smartweed, velvetleaf
Outlook (dimethenamid-P)	barnyardgrass, crabgrass, foxtail, goosegrass, witchgrass	carpetweed, pigweed, purslane, spurge
Poast (sethoxydim)	barnyardgrass, bermudagrass, crabgrass, fall panicum, foxtail, goosegrass, johnsongrass, quackgrass, volunteer cereals, wild proso millet, witchgrass	
Prefar (bensulide)	crabgrass, fall panicum, foxtail, goosegrass	
Prowl (pendimethalin)	barnyardgrass, crabgrass, fall panicum, foxtail	carpetweed, lambsquarters, pigweed, purslane
Pursuit (imazethapyr)		kochia, nightshade, pigweed, wild mustard
Pyramin (pyrazon)		henbit, lambsquarters, mustard, nightshade, pigweed, purslane, ragweed, shepherd's-purse, smartweed
Raptor (imazamox)	barnyardgrass, brome, foxtail, shattercane, volunteer cereals	cocklebur, jimsonweed, lambsquarters, morningglory, mustard, nightshade, pigweed

Table 5. Weed susceptibility to herbicides labeled for use in vegetable crops (cont.)

	Weeds controlled	
Herbicide	Grasses	Broadleaves
Reflex (fomesafen)		cocklebur, horsenettle, jimsonweed, ladysthumb, morningglory, mustard, nightshade, pigweed, purslane, ragweed
Resource (flumiclorac)		jimsonweed, pigweed, prickly sida, ragweed, velvetleaf
Ro-Neet (cycloate)	barnyardgrass, crabgrass, foxtail	henbit, lambsquarters, nightshade, pigweed, purslane, shepherd's-purse
Roundup Ultra Max, Touchdown, others (glyphosate)	most annual and perennial grasses and broadleaves	See discussion of reduced-tillage systems.
Sandea (halosulfuron)		cocklebur, lambsquarters, nutsedge, pigweed, ragweed, smartweed, sunflower, velvetleaf
Select (clethodim)	barnyardgrass, bluegrass, crabgrass, downy brome, fall panicum, foxtail, goosegrass, sandbur, shattercane, volunteer cereals, wild proso millet, wooly cupgrass	
Sencor (metribuzin)	crabgrass, downy brome, foxtail, seedling johnsongrass	chickweed, jimsonweed, lambsquarters, pepperweed, pigweed, prickly sida, purslane, ragweed, smartweed
Sinbar (terbacil)	annual bluegrass, barnyardgrass, crabgrass, foxtail, seedling johnsongrass	chickweed, dandelion, henbit, jimsonweed, knotweed, lambsquarters, pepperweed, pigweed, plantain, purslane, ragweed, shepherd's-purse, wild mustard
Spartan (sulfentrazone)		amaranth, cocklebur, galinsoga, jimsonweed, ladysthumb, lambsquarters, morningglory, nightshade, pigweed, purslane, shepherd's-purse, sida, smartweed
Spin-aid (phenmedipham)		chickweed, groundcherry, lambsquarters, purslane, ragweed, shepherd's-purse, wild mustard
Starane		chickweed, cocklebur, hemp dogbane, morningglory, purslane, common ragweed, sunflower, velvetleaf
Stringer (clopyralid)		Canada thistle, cocklebur, dandelion, dock, horseweed, jimsonweed, ladysthumb, nightshade, prickly lettuce, ragweed, sorrel, sowthistle, wild buckwheat

Table 5. Weed susceptibility to herbicides labeled for use in vegetable crops (cont.)

	Weeds controlled	
Herbicide	Grasses	Broadleaves
Sutan+ (butylate + safener)	barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, shattercane, seedling johnsongrass	
Thistrol (MCPB)		annual morningglory, Canada thistle, lambsquarters, pigweed, smartweed, sowthistle
Touchdown (glyphosate)	many annual and perennial grasses and broadleaves	See discussion of reduced-tillage systems.
Treflan (trifluralin)	annual bluegrass, barnyardgrass, crabgrass, foxtail, goosegrass, seedling johnsongrass	carpetweed, chickweed, knotweed, lambsquarters, pigweed, purslane

Table 6. Common names of herbicides and corresponding trade names

Common name	Trade name	Common name	Trade name
2,4-D amine	several names	glyphosate	Roundup Ultra Max, Touchdown
acetolachlor	Harness, others		
alachlor	Lasso, others	halosulfuron	Permit, Sandea
atrazine	AAtrex, others	imazamox	Raptor
benefin	Balan	imazethapyr	Pursuit
bensulide	Prefar	isoxaflutole	Balance
bentazon	Basagran	linuron	Linex, Lorox
bromoxynil	Buctril	MCPB	Thistrol
butylate + safener	Sutan+	mesotrione	Callisto
carfentrazone	Aim	metribuzin	Sencor
clethodim	Select	napropamide	Devrinol
clomazone	Command	naptalam	Alanap
clopyralid	Stringer	nicosulfuron	Accent
cycloate	Ro-Neet	oxyfluorfen	Goal
DCPA	Dacthal	paraquat	Gramoxone Inteon
dicamba	Banvel, Clarity	pendimethalin	Prowl
diflufenzopyr + dicamba	Distinct	phenmedipham	Spin-aid
dimethenamid	Frontier, Outlook	primisulfuron	Beacon
diuron	Karmex, others	pronamide	Kerb
EPTC	Eptam	pyrazon	Pyramin
EPTC + safener + extender	Eradicane Extra	quizalofop	Assure II
		rimsulfuron	Matrix
ethalfluralin	Curbit	sethoxydim	Poast
fluazifop-butyl	Fusilade DX	S-metolachlor	Dual Magnum
flumiclorac	Resource	sulfentrazone	Spartan
flumioxazin	Chateau	terbacil	Sinbar
fluroxypyr	Starane	topramezone	Impact
fomesafen	Reflex	trifluralin	Treflan, others

Table 7. Rotation restrictions for common vegetable crops

Herbicide				Rotation restriction (months)[c]											
Trade name	Active ingredient	Site of action[a]	Crop use[b]	Sweet corn	Pop-corn	Dry beans	Snap beans	Peas	Potato	Tomato	Pepper	Cu-cum-bers	Pump-kins	Water-melon	Cole crops
AAtrex, others	atrazine	PSI	c	AT	AT	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Accent	nicosulfuron	ALSI	c	10[d]	10	10	10	10	10/18[e]	10/18	10/18	10/18	10/18	10/18	10/18
Assert	toluic acid	ALSI	w	15	15	15	15	15	15	15	15	15	15	15	15
Basis	rimsulfuron + thifensulfuron	ALSI	c	10	10	8	8	8	4	18	18	18	18	18	18
Beacon	primisulfuron	ALSI	c	8	8	8	18	8	18	18	18	18	18	18	18
Bicep	atrazine + metolachlor	PSI + CHA	c	AT	AT	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Broadstrike + Dual	flumetsulam + metolachlor	ALSI CHA	c, s	18	9	4	26FB	4	12	26FB	26FB	26FB	26FB	26FB	26FB
Broadstrike + Treflan	flumetsulam + trifluralin	ALSI DNA	c	18	9	4	26FB	4	12	26FB	26FB	26FB	26FB	26FB	26FB
Canopy	chlorimuron + metribuzin	ALSI PSI	s	18	NY	12	12	12	30	10[f]	30	18	18	18	30
Canopy XL	chlorimuron + sulfentrazone	ALSI CBI	s	18	NY	12	30	30	30	12[f]	30	18	30	18	18/30[g]
Classic	chlorimuron	ALSI	s	18	NY	9	9	9	30	9[f]	30	18	18	18	18/30[g]
Command	clomazone	PBI	s	9	9	9	9	AT[h]	12	9[f]	AT	9	AT	9	12
Commence	clomazone + trifluralin	PBI DNA	s	9	9	9	NNY	9	9	9[f]	9	9	9	9	NNY
Concert SP	thifensulfuron + chlorimuron	ALSI	s	9FB	9FB	9	9FB	9FB	9FB	9[f]	9FB	9FB	9FB	9FB	9FB
Contour	imazethapyr	ALSI	c	18	18	9	40FB	9	26	40FB	40FB	40FB	40FB	40FB	40FB
Cover, others	sulfentrazone	CBI	s	18	NY	12	30	30	30	30	30	18	18	18	18/30
Detail	imazaquin + dimethenamid	ALSI CHA	s	18	18	11	18	18	18/26[i]	18/26	18	18	18	18	18/26
DoublePlay	EPTC + acetochlor	THC	c	NNY	AT	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY

Table 7. Rotation restrictions for common vegetable crops (cont.)

Herbicide				Rotation restriction (months)[c]											
Trade name	Active ingredient	Site of action[a]	Crop use[b]	Sweet corn	Pop-corn	Dry beans	Snap beans	Peas	Potato	Tomato	Pepper	Cu-cum-bers	Pump-kins	Water-melon	Cole crops
Express	tribenuron	ALSI	w	2	2	2	2	2	2	2	2	2	2	2	2
Finesse	chlorsulfuron + metsulfuron	ALSI	w	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
FirstRate	cloransulam	ALSI	s	30	9	9	30	9	30	30	30	30	30	30	30
FlexStar	fomesafen	CBI	s	10	10	10	10	10	18	18	18	18	18	18	18
Frontier	dimethenamid	CHA	c, s	AT	AT	AT	NY	NY	NY	NY	NY	NY	NY	NY	NY
Harmony Extra	thifensulfuron + tribenuron	ALSI	w	2	2	2	2	2	2	2	2	2	2	2	2
Harness	acetochlor	CHA	c	NY	AT	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Hornet	flumetsulam	ALSI	c	18	10.5	10.5	26FB	18	18	26FB	26FB	26FB	26FB	26FB	26FB
Lariat, Bullet	atrazine + alachlor	PSI CHA	c	AT	AT	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Liberty	glufosinate	AASI	c, s	3	3	3	3	3	3	3	3	3	3	3	3
Lightning	imazethapyr + imazapyr	ALSI	c	18	18	9.5	40FB	9.5	26	40FB	40FB	40FB	40FB	40FB	40FB
Marksman	atrazine + dicamba	PSI GR	c	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Passport	imazethapyr trifluralin	ALSI DNA	s	18	18	AT	AT	AT	26	26	26	18	18	18	26
Permit	halosulfuron	ALSI	c	3	3	9	9	9	9	6[f]	10	9	9	36	11/18
Pinnacle	thifensulfuron	ALSI	s	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Pursuit	imazethapyr	ALSI	c, s	18[j]	18[j]	4	4	40FB	40FB	40FB	40FB	40FB	40FB	40FB	40FB
Pursuit Plus	imazethapyr pendimethalin	ALSI DNA	c, s	18	18	4	4	40FB	26	40FB	40FB	40FB	40FB	40FB	40FB
Python	flumetsulam	ALSI	c, s	18	9	4	26FB	4	12	26FB	26FB	26FB	26FB	26FB	26FB
Raptor	imazamox	ALSI	s	9	9	9	9	9	9	9	9	9	9	9	9/26FB[k]
Reflex	fomesafen	CBI	s	10	10	10	10	10	18	18	18	18	18	18	18
Reliance STS	thifensulfuron	ALSI	s	9/18[l]	9	9	9	9	30	9[f]	30	9	9	9	18/30[g]
Resolve	imazethapyr dicamba	ALSI GR	c	9/18	18	9.5	9.5	9.5	26	40FB	40FB	40FB	40FB	40FB	40FB
Scepter	imazaquin	ALSI	s	18	18	11	11	11	18/26[i]	18/26	18	18	18	18	18/26
Scorpion II	flumetsulam + clopyralid	ALSI GR	c	10.5	10.5	10.5	26FB	18	18	26FB	26FB	26FB	26FB	26FB	26FB

Table 7. Rotation restrictions for common vegetable crops (cont.)

Herbicide				Rotation restriction (months)[c]											
Trade name	Active ingredient	Site of action[a]	Crop use[b]	Sweet corn	Pop-corn	Dry beans	Snap beans	Peas	Potato	Tomato	Pepper	Cu-cum-bers	Pump-kins	Water-melon	Cole crops
Shotgun	atrazine + 2,4D	PSI GR	c	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Squadron	imazaquin + pendimethalin	ALSI DNA	s	18	18	11	11	11	18/26[i]	18/26	18	18	18	18	18/26
Steel	imazaquin imazethapyr pendimethalin	ALSI ALSI DNA	s	18/26[i]	18/26	11	11	11	26	40FB	40FB	40FB	40FB	40FB	40FB
Stringer	clopyralid	GR	c, w	10.5	10.5	10.5	18	18	18	18	18	18	18	18	10.5
Surpass 100	acetolachlor + atrazine	CHA	c	NNY	AT	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Synchrony STS	chlorimuron	ALSI	s	18	9	9	9	9	30	9[f]	30	18	18	18	18/30[g]
TopNotch	acetolachlor	CHA	c	NNY	AT	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Touchdown	sulfonium	ALSI	c, s	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Tri-Scept	imazaquin + trifluralin	ALSI DNA	s	18	18	11	11	11	18/26[i]	18/26	18	18	18	18	18/26
Turbo	metolachlor + metribuzin	CHA	s	8	8	12	12	8	8	12	12	12	12	12	12

[a]Sites of action include PSI = photosynthetic inhibitor; ALSI = ALS-inhibiting; CHA = chloroacetamide; THC = thiocarbamate; DNA = dinitroaniline; CBI = chlorophyll-biosynthesis inhibitor; PBI = pigment-biosynthesis inhibitor; AASI = amino acid–synthesis inhibitor; GR = growth regulator.

[b]Crops include c = corn; s = soybean; w = wheat.

[c]Rotation restrictions include AT = anytime; NNY = not next year; FB = field bioassay (the first number is the months that must pass before the bioassay); NY = next year.

[d]Except Merit, Carvinal, Sweet Success sweet corn cultivars, where the restriction is 15 months.

[e]The rotation restriction is 10 months at pH $\leq$ 6.5 and 18 months at pH > 6.5.

[f]Transplanted tomatoes only.

[g]Cabbage / other cole crops.

[h]If more than 1.33 pt / acre, then 9 months.

[i]Rotation restriction for southern or northern Illinois, respectively.

[j]Some sweet corn and popcorn varieties may be planted the year following an application of Pursuit.

[k]Cabbage and broccoli may be planted 9 months after Raptor applications. Other cole crops have a 26-month rotation restriction and require a field bioassay.

[l]9 months for processing sweet corn or 18 months for sweet corn.

Environmental and Health Hazards of Herbicides

Nontargeted effects can occur from the use of herbicides. With the increased attention directed toward such nontargeted effects, it is very important to educate yourself and consider nontargeted effects when designing weed-management systems. This overview discusses some of the potential environmental and health hazards of herbicides. More detailed information is contained in herbicide labels, other chapters of this handbook, and trade publications.

Environmental Hazards

Adverse environmental effects from herbicides can have long-term consequences that are difficult to correct and must be avoided. Some environmental hazards, such as herbicide drift and carryover, affect mainly your operation, while others, such as water contamination, affect all the residents of Illinois. The following section discusses some of the potential hazards and methods to avoid them.

Herbicide Carryover. Herbicide carryover from persistent herbicides is a particular problem to growers of vegetable crops. Some vegetable-crop herbicides and many common soybean, corn, and wheat herbicides can persist and injure following crops. Persistent herbicides can kill vegetable plants, reduce growth, affect fruiting, or injure root systems. Root-system injury may not show up until the plants are under stress and the plants suddenly die.

Generally, the biggest problems are ALS-inhibiting herbicides (sulfonylureas and imidazolinones). ALS-inhibiting herbicides can be used on corn, soybeans, and wheat. Examples of sulfonylurea herbicides are Classic, Canopy, and Accent, while some imidazolinones are Pursuit, Scepter, and Raptor. These herbicides inhibit branch-chain amino acid synthesis. Injury from ALS-inhibiting herbicides appears as chlorosis of the growing points and new growth, along with root-growth inhibition. Another herbicide that can persist and injure vegetable crops is atrazine. It inhibits photosynthesis in plants, causing the older leaves to turn yellow. Atrazine is a very common corn (including sweet corn and popcorn) herbicide that is contained in a wide variety of products.

Some ALS-inhibiting herbicides have a very long persistence. Generally, rotation restrictions provide an indication of how long after its application an herbicide persists. For example, Passport, Pursuit, and others require that you wait 40 months after they are applied (Table 7) and then successfully conduct a field bioassay before planting vegetable crops. Atrazine generally requires that you plant no other crops the year following an application.

Herbicide persistence is dependent on soil and environmental factors. Breakdown of herbicides in the soil occurs either by microbial degradation or chemical hydrolysis. Both factors require that the soil be moist and temperatures warm. Thus, cool temperatures and dry conditions slow herbicide degradation. Soil pH and organic matter are also important for herbicide degradation. For example, at pHs above 6.5, degradation of Accent is slowed considerably. Because these soil and environmental influences affect herbicide degradation and persistence, rotation restrictions should be used as minimum guidelines.

What is a field bioassay? It is the planting of a test strip of the sensitive vegetable crop across the treated field and letting it grow to maturity. It is a way of determining if sufficient herbicide residual remains to injure a sensitive follow crop. Field bioassays should be conducted after you have waited the number of months prescribed by the herbicide label.

How do you conduct a bioassay? Generally, strips of a test crop are planted across a field. Several rows of the test crop should be planted in each strip, and several strips should be planted in the field. The test strips should be planted perpendicular to the direction the herbicide was originally applied. Test strips should include field margins and ends, low areas, knolls, and sections of the field varying in soil characteristics such as type, organic matter, and pH.

Avoid carryover because correcting carryover problems once they occur is virtually impossible. The best solution for avoiding herbicide carryover injury is selecting fields that have not had persistent herbicides. Fields that previously were in pasture, CRP land, or vegetables (besides sweet corn) are unlikely to have persistent herbicides. Many wheat herbicides have short persistence and do not injure following crops. If you must use fields that had corn or soybeans, choose those having Roundup Ready crops. Roundup tightly binds to the soil and does not injure rotational crops.

Herbicide Drift. Another frequent hazard to vegetable growers is crop injury from herbicide drift. The term *drift* refers to movement of herbicides off the site where they were applied. Drift can occur either during herbicide application (spray drift) or because the herbicide volatilizes after being applied to plants (vapor drift). Both types of drift can injure your vegetable crops. Vegetables are extremely sensitive to some herbicides, such as growth regulators. This extreme sensitivity means that very low concentrations of growth-regulator herbicides can drift and injure your crop.

What are growth-regulator herbicides? They are herbicides that mimic auxins. Auxins are natural chemicals that govern growth in plants. They regulate shoot and root response to gravity, shoot branching,

Table 8. Common and trade names of some herbicides that might injure vegetable crops (This list is not all-inclusive. Other herbicides may also injure vegetables.)

Growth regulators			*Glyphosate*	*ALS inhibitors*	
2,4-D	Dicamba	Others		Sulfonylurea	Imidazolinone
Amine 4	Banvel	Amitrole T	Accord	Accent	Assert
Barrage	Clarity	Rhomene	Bronco	Ally	Contour*
Brush-Rhap	Fallow Master*	Sword	Landmaster*	Basis	Lightning
Crossbow*	Marksman*	Telone C-17	Protocol	Basis Gold*	Pursuit
Esteron	OpTill*		Ranger	Beacon	Pursuit Plus
Formula 40	Resolve*		Rodeo	Canopy*	Raptor
Grazon*			Roundup Ultra Max	Classic	Resolve
Landmaster*				Concert*	Scepter
Phenoxy 088*		*Pigment inhibitors*		Escort	Squadron*
Salvo				Exceed	Steel*
Scorpion III*		Command		Express	Tri-Scept*
Shotgun*		Commence		Finesse*	
Tiller*				Glean	
Weedar				Harmony	
Weedmaster*				Matrix	
Weedone				Oust	
Weedone 638*				Permit	
2 Plus 2				Pinnacle	
				Synchrony*	

*A prepackaged mixture also containing other active ingredients.

leaf growth, and fruit development. Tolerant crops are able to degrade growth regulators into nonactive compounds, while most vegetables cannot metabolize these herbicides. Growth-regulator herbicides are inexpensive and widely applied to corn, soybeans, wheat, turf, and rights-of-way. In agricultural settings, growth-regulator herbicides are used before planting for burndown in no-till corn and soybeans, at planting in corn, and postemergence in both corn and wheat. Growth-regulator herbicides used in turf or by railroads, utilities, and townships on rights-of-way can also drift to injure vegetables. Growth-regulator herbicides can drift up to a mile and cause serious damage to grapes, tomatoes, peppers, other vege- tables, fruit crops, and ornamental plants. Table 8 lists the trade names of some growth-regulator herbicides.

The most common growth-regulator herbicides are 2,4-D and dicamba. The ability of 2,4-D and dicamba to drift or volatilize depends on the formulation. The ester formulations of 2,4-D (that is, Barrage, Estron, and Salvo) are more likely to volatilize and drift than are amine formulations (that is, Formula 40, Amine 4, and Savage). Ester formulations of 2,4-D are widely used because they have cheaper cost, greater penetration, and better activity against weeds than other formulations. Dicamba formulations also differ in their volatility. The older Banvel formulation appears to volatilize more than the newer Clarity formulation of dicamba.

Are other herbicides besides growth regulators likely to injure vegetables? Generally, despite their reactions to growth regulators, vegetable crops are not extremely sensitive to other herbicides, compared to the reactions of other crops (Table 9). The other herbicides of concern are glyphosate and ALS inhibitors. Both groups of herbicides translocate to and kill growing points of plants. Glyphosate is the active ingredient in Roundup Ultra Max and similar products. Glyphosate inhibits synthesis of aromatic amino acids (that is, phenylalanine and others). Roundup traditionally has been used as a nonselective herbicide for burndown prior to planting or after harvest. These application times were usually not a problem because most vegetables were not actively growing when glyphosate was applied. This situation has dramatically changed with the widespread use of Roundup-Ready corn and soybeans. Now, Roundup is often applied when vegetables are actively growing and fruiting. Vegetable crops are likely to be injured only by spray drift from nearby applications. The injury symptoms include chlorosis and death of growing points, misshapen growth, reduced survival, less fruiting, and lower fruit quality.

Table 9. Some herbicides that can be used on corn or soybeans and that are unlikely to drift and injure vegetables

Corn	Soybeans
Preemergence	
Atrazine	Broadstrike
Dual	Dual
Eradicane	Frontier
Frontier	Harness
Harness	Lasso
Lasso	Lexone/Sencor
	Prowl
	Treflan
Postemergence	
Atrazine	Basagran
Basagran	Blazer
Buctril	Poast
	Prism
	Reflex
	Select

Herbicides containing clomazone (Command and Commence) can cause bleaching of nearby sensitive plants. This herbicide inhibits pigment synthesis in plants. Plants usually recover from the bleaching caused by clomazone. Often, yields are not effected by the drift. Older formulations of Command were volatile and required incorporation soon after application. The current 3ME formulation of Command is less volatile and less likely to drift and injure susceptible plants.

Many vegetable crops are also sensitive to acetolactate synthase (ALS)–inhibiting herbicides. These herbicides are sulfonylureas (that is, Classic, Accent, and Permit) and imidazolinones (that is, Pursuit and Scepter). They inhibit the key enzyme (acetolactate synthase) that controls branch-chain amino acid synthesis. ALS inhibitors are widely used in corn, soybean, and wheat production. They are applied both before planting and postemergence at extremely low rates. The high biological activity of ALS-inhibiting herbicides increases the likelihood of drift. Injury symptoms from ALS-inhibiting herbicides are similar to those from glyphosate, except root injury is more likely. Generally, it is believed that vegetable-crop injury from ALS inhibitors is likely only from very nearby applications.

What can you do about herbicide drift? You must work to prevent drift because once vegetables are injured there is no cure. Do not cause a drift problem yourself. Work with your neighbors to minimize the potential for drift from nearby applications. Spray only on calm days, and use drift inhibitors when appropriate. Minimize drift by applying herbicides with nozzles that produce large droplets. Use less-volatile forms of herbicides, especially 2,4-D. Spray Command (clomazone), dicamba, and 2,4-D when the temperature is expected to be lower than 80°F for several days after treatment. Avoid applying Command or other volatile soil-applied herbicides to wet soils, and incorporate soon after application. Apply herbicides unlikely to injure your vegetables (Table 9). Use preemergent herbicides such as Lasso, Dual, Harness, Frontier, Treflan, and Prowl, which are effective only against emerging seedlings. Drift from photosynthetic inhibitors such as Attrex (atrazine), Sencor, and Lorox, along with contact herbicides such as Basagran, Blazer, Reflex, and Authority, does not cause long-term damage to vegetables. These chemicals might cause leaf burn but will not translocate to growing points or fruit.

Spray-Tank Residuals. Dicamba or 2,4-D residues in spray tanks also can injure susceptible vegetable crops. Carefully follow label directions for cleaning spray equipment after using dicamba or 2,4-D. If possible, do not use the same spray equipment to apply 2,4-D or dicamba that you use to apply other pesticides.

Herbicide Resistance. There are now more than 50 documented reports worldwide of weeds that have developed resistance to herbicides. Herbicide resistance tends to occur when a persistent herbicide is used year after year in the same field. Thus, continued use of the same herbicide on a perennial crop such as asparagus should be avoided. Many of the resistance problems have occurred with triazine herbicides, such as simazine and atrazine. The labels of those herbicides contain information about avoiding resistance problems.

Approaches to avoid herbicide resistance combine herbicides with mechanical (cultivation) and cultural (crop rotation) weed-management practices. Rotate between or use tank mixes of herbicides with different mechanisms of killing the plant. For example, in asparagus, rotate between Sencor and Treflan. Use tillage to control weeds that escape from herbicide applications. Especially important in minimizing any weed resistance that does occur is scouting your fields, paying special attention to any patches of a weed normally controlled by the herbicide.

Water Quality. Residues of some herbicides, such as atrazine, metolachlor, alachlor, cyanazine, and metribuzin, have been found in surface water or groundwater. The levels detected have normally been low, but contamination of water resources is a growing concern. For example, groundwater contamination from pesticides and nitrates is of particular concern in areas of the state with sandy soils and shallow groundwater.

Factors determining the potential for groundwater and surface-water contamination include herbicide solubility in water, rate of degradation, volatility, and

tendency for the herbicide to attach to soil particles or organic matter. Herbicides that have high water solubility and long persistence are of particular concern.

Site characteristics (soil type, soil depth, water-table depth, slope, and weather) also can lead to contamination of water resources from herbicides. You should be aware of the potential problem of herbicide contamination and take all possible steps to avoid contaminating surface and subsurface water resources.

Disposing of Herbicides and Containers

Surplus Herbicides. If possible, use surplus herbicide mixtures by applying them to labeled crops that have the same weed problems. Never drain surplus pesticides in any location where they can contaminate groundwater or surface-water supplies. Avoid creating surplus tank mixes by accurately measuring the treatment area and mixing the correct amount of pesticide. If a large amount of surplus pesticide is generated, contact the Illinois EPA Division of Land Pollution Control for instructions about disposal.

Pesticide Containers. Rinse all empty containers, regardless of their type, three times before disposal. Dump rinse water into the tank. Puncture or break triple-rinsed containers to facilitate drainage and to prevent reuse for any purpose. Then dispose of containers according to label directions and local regula-tions, with regard for the protection of water resources.

Health Hazards

Health hazards from exposure to pesticides may be divided into acute and chronic effects, according to the duration and amount of exposure.

Acute Effects. Acute effects or poisoning occurs soon after exposure to large amounts of a pesticide. Effects of this type are dangerous to you, your family, and your workers. The potential for human or animal poisoning from pesticides can be reduced by careful storage and handling. Keep pesticides in a separate area, room, or building used only for storage. The storage area should be dry and ventilated. Keep all entrances to the area locked at all times to protect children, other people, and animals. **Caution**: Do not store herbicides together with insecticides or fungicides. Remove only the pesticide to be used in one day and, after use, return the pesticide to the storage area. Follow label directions when handling pesticides. Pay particular attention to sections on protective-clothing requirements and any field-reentry limitations.

Herbicide Residues in Vegetables

The issue of pesticide residues in vegetables is currently receiving intense public attention. Many of the herbicides used in vegetable crops are older products that were registered before current toxicological and environmental standards were established by the USEPA. Congress has required the USEPA to re-register these older products to bring the data up to current toxicological and environmental standards, causing some companies to remove products from the market.

Data exist that some herbicides (and other pesticides) potentially cause adverse health effects, such as cancer from chronic (long-term) exposure. There is controversy about the reliability and importance of these data. Groups that are particularly concerned about pesticide residues in vegetables include the National Resources Defense Council, National Coalition Against Misuse of Pesticides, and Americans for Safe Food. Because customers may question you, it is recommended that you stay up-to-date on this issue. The groups listed have information reflecting their views. Information reflecting food industry views is also available from groups such as the Alliance for Food and Fiber, the Food Marketing Institute, and the Center for Produce Quality.

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7

Plant Disease Management for Commercial Vegetable Crops

Updates for 2008

The following list briefly highlights some of the changes to the chapter for this edition:

- Sovran (kresoxim-methy) has been labeled for use on cucurbits for control of powdery mildew and gummy stem blight.
- Proline 480SC has been registered for use on chickpea and lentils for control of Ascochyta blight.
- Cuprofix Ultra 40 Disperss (copper sulfate) has received organic status with the USDA National Organic Program.
- Tables 1 and 3 of this chapter were revised.

Disease Management

Successful control of vegetable diseases requires an integrated program that includes the use of resistant varieties, crop rotation, balanced soil fertility, weed and insect control, and proper crop culture, as well as the proper selection, timing, and method of applying fungicides, bactericides, or nematicides. Economical control depends on establishing an overall disease-management system for the entire farm. Keeping careful records of the crops planted, the problems encountered, and the pesticides used is important.

Because many disease problems originate with seeds or transplants, growers should follow the seed-treatment recommendations given in this chapter and in *Report on Plant Disease (RPD)* no. 915, "Vegetable Seed Treatment" (available from the Department of Crop Sciences, N-533 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801), or be sure to obtain planting material that is certified as disease free.

This chapter lists the registered fungicides and application intervals for various vegetable crops as approved by the Food and Drug Administration (FDA) and the U.S. Environmental Protection Agency (USEPA) as of October 15, 2006, to the best of our knowledge. Tables 1 and 2 give the number of days between the last application at the normal rate and harvest, as well as other restrictions to keep residues within the tolerances set by the FDA. Refer to current labels for information on rates, timing, and methods of application, as well as for information on follow-up crops and other restrictions.

The listing of a chemical as approved for use on a particular crop does not mean that University of Illinois Extension or the Office of Research recommends its use for that crop. Our specific recommendations for disease control are given in Table 3.

In some instances, a tolerance has been set, but a definite interval has not been established. The absence of an interval for a crop in the listings does not necessarily mean that the fungicide may not be used on that crop. To ensure that the crop produced does not exceed the tolerance, the use of the fungicide would require a restriction such as "Do not apply after first blooms appear" or "Do not apply after edible parts form." This information appears on the product label.

In a few cases, the interval and dosage have been established, but the allowable residue concentration has not been determined. Again, this does not mean that the fungicide may not be used on the crops for which the fungicide is labeled. It does mean, however,

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The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.

Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.

that until the tolerance is established, it must be considered zero. These cases are reviewed each year, and some are canceled when the chemical manufacturer supplies the USEPA with additional data.

Growers must follow a program of disease control ensuring that the vegetables produced do not contain excessive fungicide residues. Vegetables marketed with residues exceeding the FDA tolerances may be injurious to consumers, may be confiscated, and may subject the grower to legal action.

Growers have nothing to fear from the law so long as they use fungicides and other pesticides according to the current labels and only on the crops specified, in the amounts specified, and at the times specified. The prudent grower keeps a record of the products and trade names used, the percentage of active ingredients, dilutions, rates of application per acre, and dates of application.

Disease Diagnosis

The first step in an effective disease-management program is proper identification of the problem. This is often the most difficult, but the most important, step. Make every possible effort to ensure that the disease is accurately diagnosed. Failure in accurate identification of the problem could have severe consequences.

Fungicide Application

We recommend that the following practices be used when applying fungicides.

- Cover the foliage uniformly. *Ground application*—Apply 30 to 50 gallons per acre at 100 to 400 pounds per square inch of pressure unless recommended otherwise. Lowering the volume, pressure, or both may provide adequate coverage; but high-volume, high-pressure applications provide ideal coverage. Make sure the sprayer is functioning properly. Check the nozzles for cleanliness and wear. Boom height, accuracy of pressure gauge, agitation, and calibration should also be checked. *Aerial application*—Apply recommended amounts of pesticide in 3 to 5 gallons of water per acre. Make sure nozzles are properly aligned and clean so that uniform application is achieved. Cover a swath no wider than is reasonable for the aircraft and boom being used. Spray only those fields that are suitable for aerial application. Avoid fields of irregular shape or topography, particularly if they are bounded by power lines, trees, or other obstructions.
- Whenever possible, spray when the air is still or when wind velocity is less than 10 mph.
- Avoid situations where pesticide drift may cause needless problems.
- When it is compatible with the product label, use a spray adjuvant (surfactant). Available surfactants include Bio-Film, Bio 88, Regulaid (for systemic fungicides), Plyac, NuFilm, Chevron Spray Sticker, X-77 Spreader, Triton, and some others. Spray adjuvants are most useful on cabbage, cauliflower, Brussels sprouts, onions, and peppers.

Soil Fumigation

Follow the manufacturer's directions exactly. Fumigants work best in light, loose soils that are free of trash, clods, and lumps. Avoid recontaminating treated soil. It is best to apply fumigants during the fall before planting. In general, the soil temperature must be at least 55° to 60°F at the 6-inch depth, with a time lapse of 21 to 28 days between treating and seeding. Some fumigants require gas-tight plastic covers. Many fumigants are restricted use chemicals.

Using Nematicides

Use nematicides only where soil analysis shows a nematode problem to be present. Follow soil sampling instructions in *RPD* no. 1100, "Collecting and Submitting Soil Samples for Nematode Analysis." *RPD* no. 1100 and other *RPD*s are available from the Department of Crop Sciences, N-533 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801.

Recommended Web Resources

http://veg-fruit.cropsci.uiuc.edu, http://www.ag.uiuc.edu/~vista/pubs.html, and **http://ipm.uiuc.edu**
For information on vegetable crops in Illinois, *Illinois Fruit & Vegetable News,* current and archived issues. Includes IPM links and "Ask an Expert" section. Published weekly during the summer.

http://www.APSnet.org
Information on plant diseases. Web site of the American Phytopathological Society. News features, reports, and other public-access information, as well as subscription journals.

Table 1. Preharvest intervals (in days) and re-entry intervals for fungicides registered for use on Illinois vegetables in 2008.[a]

	acibenzolar-S-methyl	azoxystrobin	boscalid	boscalid/pyraclostrobin	chlorothalonil	cyazofamid	cymoxanil/famoxadone	cyprodinil/fludioxonil	dimethomorph	fixed copper	aluminum trifosetyl-Al	iprodione	mancozeb	maneb	myclobutanil	phosphorous acid	propamocarb	propiconazole	pyraclostrobin	thiophanate methyl	trifloxystrobin	triflumizole
Asparagus	...	100	...	...	190	...	...	...	...	...	110	...	180	...	180	0	...	...	...	...	...	...
Bean (lima)	...	0	7	...	14	...	...	7	...	0	...	b	...	30	...	0	...	...	...	28	...	...
Bean (snap)	...	0	7	...	7	...	...	7	...	0	...	b	...	...	0	0	...	...	...	14	...	...
Beet	...	0	...	...	...	...	...	...	...	0	...	...	...	...	...	...	...	...	...	...	7	...
Broccoli	7	0	0	...	7	...	...	7	0	0	3	0	...	7	...	0	...	...	...	...	...	...
Brussels sprout	7	0	0	...	7	...	...	7	0	0	3	...	...	7	...	...	...	...	...	...	...	...
Cabbage	7	0	0	...	7	...	...	7	0	0	3	0	...	7	...	0	...	...	...	...	...	...
Chinese cabbage	7	0	c	...	7	...	...	7	0	0	3	...	...	7	...	0	...	...	...	...	...	...
Cantaloupe	...	1	...	0	0	0	3	...	0	0	½	...	5	5	0	0	2	...	0	1	0	0
Carrot	...	0	0	0	0	...	...	7	...	0	...	0	...	...	...	...	...	...	0	...	7	...
Cauliflower	7	0	0	...	7	...	...	7	0	0	3	0	...	7	...	0	...	...	...	...	...	...
Celery	...	0	...	...	7	...	...	0	...	0	3	...	...	...	...	...	...	14	...	...	7	...
Collard	7	0	14	...	...	...	...	7	0	0	3	...	...	14	...	...	...	...	...	...	...	...
Cucumber	...	1	...	0	0	0	3	...	0	0	½	...	5	5	0	...	2	...	0	1	0	0
Eggplant	...	0	0	...	...	...	...	...	...	0	...	...	...	5	...	0	...	...	0	...	3	...
Endive	...	0	...	...	...	...	...	0	...	...	3	...	...	10	...	...	...	...	...	...	...	...
Kale	7	0	14	...	...	...	...	7	...	...	3	...	...	10	...	...	...	...	...	...	...	...
Lettuce (head)	...	0	0	14	...	...	3	0	0	...	3	14	...	10	...	...	2	...	...	...	...	...
Lettuce (leaf)	...	0	0	14	...	...	3	0	0	...	3	14	...	10	...	...	2	...	...	...	...	...
Mint	...	7	...	...	80	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mustard	...	0	14	...	...	...	...	7	...	0	3	...	...	...	...	...	...	...	...	...	...	...
Onion (bulb)	...	0	7	7	7	...	...	7	0	0	7	7	7	7	...	0	...	...	7	...	...	...
Onion (green)	...	0	7	7	14	...	...	7	0	0	...	...	...	7	...	0	...	...	7	...	...	...
Parsley	...	0	...	...	...	...	...	0	...	0	3	...	...	...	...	...	...	...	...	...	...	...
Parsnip	...	0	...	...	10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7	...
Peas	...	0	...	...	...	...	...	...	...	0	...	...	...	...	...	0	...	...	...	...	...	...
Pepper	...	0	0	...	...	...	3	...	...	0	...	...	...	7	...	0	5	...	0	...	3	...
Potato	...	14	30	14	7	7	14	...	4	0	...	14	14	14	...	0	14	...	3	21	7	...
Pumpkin	...	1	...	0	0	0	3	...	0	0	½	...	...	5	0	...	2	...	0	1	0	0
Radish	...	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0	...	...	...
Spinach	7	0	...	...	...	...	...	...	...	0	3	...	...	...	...	...	...	...	...	...	...	...
Squash (summer)	...	1	...	0	0	0	3	...	0	0	½	...	5	5	0	...	2	...	0	1	0	0
Squash (winter)	...	1	...	0	0	0	3	...	0	0	½	...	...	5	0	...	2	...	0	1	0	0
Sweet corn	...	7	...	...	14	...	...	...	...	...	...	...	7	7	...	...	...	14	...	...	...	...
Tomato	14	0	0	...	0	0	3	...	4	0	14	...	5	5	0	0	5	...	0	...	3	...
Turnip	7	0	...	...	...	...	...	...	...	0	...	...	...	...	...	...	...	...	...	...	7	...
Watermelon	...	1	...	0	0	0	3	...	0	0	½	...	5	5	0	0	2	...	0	1	0	0
Re-entry interval (hr)	12	4	12	12	12	12	12	12	12	24	12	24	24	24	24	4	12	24	12	12	12	12

[a]Check label directions before applying any of these pesticides.
[b]Do not apply past peak bloom.
[c]0-day PHI for napa Chinese cabbage, 14-day PHI for bok choy.

Table 2. Label information on fungicides and nematicides of less general use

Fungicide	Crops and use restrictions
Actigard (plant activator) (Actigard 50WG)	**Spinach:** downy mildew, white rust, 7 days.[a] **Tomato:** bacterial spot, bacterial speck, 14 days.[a]
Azoxystrobin (Amistar, Quadris)	**Bulb vegetables** (garlic, leek, onions, shallot); **corn** (popcorn and sweet corn); **cucurbits** (cantaloupe, chayote, Chinese waxgourd, cucumber, gourd, honeydew melon, muskmelon, pumpkin, squash, watermelon, zucchini); **eggplant; leafy vegetables** (amaranth, arugula, Brassica leafy green, cardoon, celery, celtuce, chervil, coriander, cress, dandelion, dock, edible chrysanthemum, endive, fennel, lettuce, mint, orach, parsley, purslane, radicchio, rhubarb, spinach, Swiss chard); **okra; pepper; tomatoes; vegetable—root** (beet, burdock, carrot, celeriac, chervil, chicory, ginseng, horseradish, parsley, parsnip, radish, rutabaga, salsify, skirret, turnip); **vegetable—tuberous** (arracacha, arrowroot, artichoke, burdock, canna, cassava, chayote, chufa, dasheen, ginger, leren, potato, sweet potato, tanier, turmeric, yam). Read and follow label directions.
(Dynasty)	**Corn** (pop and sweet); **legume vegetables** (field bean, kidney bean, lima bean, navy bean, pinto bean, runner bean, snap bean, wax bean), chickpea (garbanzo bean), lentil, peas (dwarf pea, edible-pod pea, English pea, field pea, garden pea, green pea, snow pea, sugar snap pea); seed treatment against seedborne and soilborne fungi.
(Protégé)	**Cucurbits** (cucumber); **corn** (pop and sweet); **legume vegetables** (field bean, kidney bean, lima bean, navy bean, pinto bean, runner bean, snap bean, was bean), chickpea (garbanzo bean) lentil, peas (dwarf, elible-pod, English, garden, green, snow, sugar, snap); seed treatment against seedborne and soilborne fungi.
Azoxystrobin + chlorothalonil (Quadris Opti)	**Bulb vegetables** (leek, onion, shallot); **carrot; celery; cucurbits** (cantaloupe, chayote, Chinese wax gourd, cucumber, gourd, honeydew, *Momordica* spp., muskmelon, pumpkin, squash, watermelon, zucchini); **dry beans** (adzuki bean, broad bean, kidney bean, lablab bean, lima bean, moth bean, mung bean, navy bean, pink bean, pinto bean, tepary bean, urd bean, yardlong bean, rice bean, running bean, jackbean, blackeyed pea, southern catjang pea, chickpea [garbanzo bean], grain lupin, lupine); **potatoes; tomatoes.** Read and follow label directions.
Azoxystrobin + propiconazole (Quilt)	**Sweet corn:** eye spot, gray leaf spot, northern corn leaf blight, northern corn leaf spot, rusts, southern corn leaf blight, 14 days.[a]
Bordeaux mixture (many trade names)	**Asparagus, beans, beet, broccoli, Brussels sprout, cabbage, carrot, casaba melon, celery, collard, crenshaw melon, cress, cucumber, eggplant, honeydew melon, horseradish, kale, muskmelon, mustard, pepper, Persian melon, potato, pumpkin, radish, rape, rutabaga, spinach, squash, tomato, turnip, watermelon.** Read and follow label directions.

Table 2. Label information on fungicides and nematicides of less general use (cont.)

Fungicide	Crops and use restrictions
Boscalid (Endura)	**Beans** (dry, succulent): Asochyta blight, Botrytis gray mold, rust, white mold, 7 days.[a] **Bulb vegetables** (garlic, leek, onion): purple blotch, Botrytis leaf blight, 7 days.[a] **Carrot:** Alternaria leaf spot, 0 days.[a] **Fruiting vegetables** (eggplant, ground cherry, pepino, pepper, tomatillo, tomato): early blight, Botrytis gray mold, 0 days.[a] **Lettuce:** lettuce drop (*Sclerotinia* spp.), Botrytis rot, Rhizoctonia bottom rot, 14 days.[a] **Potato:** early blight, white mold, 30 days.[a] **Head and stem Brassicas** (broccoli, Brussels sprout, cabbage, Chinese cabbage, Chinese mustard, cauliflower, kohlrabi): Alternaria blight, gray mold, Sclerotinia stem rot, powdery mildew, Rhizoctonia bottom rot, 0 days.[a] **Leafy Brassica green** (broccoli, Chinese cabbage, kale, mustard greens, mustard spinach, rape greens): Alternaria blight, gray mold, Sclerotinia stem rot, powdery mildew, Rhizoctonia bottom rot, 14 days.
Captan (many)	**Beans** (snap, dry, cowpeas), **beet** (garden), **broccoli, Brussels sprout, cabbage, cantaloupe, cauliflower, corn** (sweet), **crucifers** (collard, kale, mustard, radish, rape, turnip), **cucumber, lentils, muskmelon, peas, pepper, pumpkin, spinach, squash, Swiss chard, watermelon:** seed protectant. Read and follow label directions.
Copper fungicides[b]	
copper sulfate (many)	**Beans, beet, cantaloupe, carrot, celeriac, celery, cucumber, eggplant, honeydew melon, muskmelon, onion, pea, pepper, Persian melon, potato, pumpkin, spinach, squash, tomato, watermelon.** Read and follow label directions.
copper ammonium carbonate (Copper-Count N)	**Beans, cabbage, cantaloupe, carrot, celery, cucurbits, eggplant, honeydew melon, lettuce, onion, peas, pepper, potato, squash, tomato, watermelon.** Read and follow label directions.
copper hydroxide (Kocide DF, Kocide 4.5LF, Kocide 101, Kocide 2000)	**Beans, broccoli, Brussels sprout, cabbage, cantaloupe, carrot, cauliflower, celery, cucumber, eggplant, lettuce, muskmelon, onion, peas, pepper, potato, pumpkin, squash, tomato, watermelon.** Read and follow label directions.
copper oxychloride (many)	**Beans, beet, broccoli, Brussels sprout, cabbage, cantaloupe, carrot, casaba melon, cauliflower, celery, crenshaw melon, cucumber, eggplant, honeydew melon, lettuce, muskmelon, onion, peas, Persian melon, potato, pumpkin, spinach, squash, tomato, watermelon.** Read and follow label directions.
tribasic copper sulfate (many)	Read and follow label directions.
Cyazofamid (Ranman)	**Cucurbits:** downy mildew and Phytophthora blight, 0 days.[a] **Potato:** late blight, 7 days.[a] **Tomato:** late blight, 0 days.[a]

Table 2. Label information on fungicides and nematicides of less general use (cont.)

Fungicide	Crops and use restrictions
Cymoxanil (Curzate 60DF)	**Cucurbits:** downy mildew, 3 days.[a] **Potato:** late blight, 14 days.[a] **Tomato:** late blight, 3 days.[a] Read and follow label directions.
Cyprodinil (Switch 62.5WG)	**Beans** (dry and succulent, except cowpeas): gray mold, white mold. **Brassicas** (broccoli, Brussels sprout, cabbage, cauliflower, collard, kale, kohlrabi, mustard, rape, turnip): Alternaria leaf spot, Cercospora leaf spot, powdery mildew. **Bulb vegetables** (garlic, leek, onion): black mold *(Aspergillus niger)*, Botrytis leaf blight, neck rot, purple blotch, Stemphylium leaf blight. **Herbs:** Alternaria leaf spot, Botrytis leaf blight, Fusarium blight. **Leafy vegetables** (amaranth, celery, endive, lettuce, parsley, purslane, rhubarb, Swiss chard): Alternaria leaf spot, basal rot *(Phoma exigua)*, gray mold, powdery mildew, Sclerotinia rot.
Dimethomorph (Acrobat 50WP, Forum 4.18 SC)	**Bulb vegetables** (garlic, leek, onion, shallot): downy mildew. **Cucurbit vegetables** (cantaloupe, chayote, Chinese wax gourd, citron melon, cucumber, gherkin, gourd, muskmelon, pumpkin, squash, watermelon, zucchini): downy mildew, Phytophthora blight and crown rot. **Fruiting vegetables** (eggplant, pepino, pepper, tomatillo): Phytophthora blight. **Leafy Brassica greens:** downy mildew. **Lettuce** (head and leaf): downy mildew. **Potato:** late blight. **Tomato:** late blight.
Ethoprop (Mocap)	**Beans** (snap and lima), **cabbage, corn** (sweet), **cucumber, potato, sweet potato**: for nematode control. Read and follow label directions.
Famoxadone + cymoxanil (Tanos)	**Cucurbits** (cantaloupe, cucumber, honeydew melon, muskmelon, pumpkin, summer squash, watermelon, winter squash): Alternaria leaf blight, anthracnose, bacterial fruit blotch, downy mildew, Phytophthora blight, 3 days.[a] **Lettuce:** downy mildew, 3 days.[a] **Pepper** (all varieties): bacterial soft rot, bacterial spot, Phytophthora blight (foliar and fruit phase only), 3 days.[a] **Potato:** brown spot, early blight, late blight, 14 days.[a] **Tomato:** anthracnose, bacterial spot, bacterial speck, buckeye rot (Phytophthora species), early blight, leaf mold, late blight, Septoria leaf spot, target spot, 3 days.[a]
Fenamidone (Reason 500SC)	**Bulb vegetables** (garlic, leek, onion, shallot): for control of downy mildew and purple blotch. Apply on 5- to 10-day intervals. Do not apply within 7 days of harvest. **Cucurbits:** for control of Alternaria leaf spot and downy mildew. Apply on 5- to 10-day intervals. Do not apply within 14 days of harvest. **Lettuce:** for control of downy mildew. Apply on 5- to 10-day intervals. Do not apply within 2 days of harvest.

Table 2. Label information on fungicides and nematicides of less general use (cont.)

Fungicide	Crops and use restrictions
Fenamidone (cont.) (Reason 500SC) (cont.)	**Potato and other tuberous and corm vegetables** (artichoke, canna, cassava, chayote, ginger, sweet potato, yam): for control of early blight, late blight, and white rust. Read and follow label directions. Do not apply within 14 days of harvest. **Tomato:** for control of early blight, late blight, and Septoria leaf spot. Apply at 5- to 10-day intervals. Do not apply within 14 days of harvest.
Fenamiphos (Nemacur 15G)	**Brussels sprout, cabbage, eggplant, garlic, okra, pepper** (non-bell): for nematode control. Read and follow label directions.
Fludioxonil (Maxim 4FS)	**Sweet corn:** seed treatment for seedborne and soilborne fungi causing seed decay, damping-off, and seedling blights. Read and follow label directions.
(Maxim)	**Potato:** potato seed protectant. Read and follow label directions.
Fosetyl-AL (Aliette)	**Broccoli, Brussels sprout, cabbage, Chinese broccoli, Chinese cabbage** (bok choy and Napa), **Chinese mustard cabbage, cauliflower, collard, kale, kohlrabi, mustard greens, mustard spinach, rape greens:** downy mildew, 3 days.[a] **Chinese waxgourd, citron melon, cucumber, gherkin, gourd** (edible), ***Momordica* spp., muskmelon, pumpkin, summer and winter squash, watermelon:** downy mildew, 0 days (12 hours).[a] **Ginseng:** Phytophthora root rot, Alternaria leaf blight, 31 days.[a] Read and follow label directions. **Leafy vegetables** (except Brassica vegetables): downy mildew, 3 days.[a] **Onion** (dry bulb): downy mildew, 7 days.[a] **Tomato:** Phytophthora root rot, damping-off (*Pythium* spp.).
Iprodione[c] (Rovral)	**Beans:**[d] gray mold *(Botrytis)*, white mold *(Sclerotinia)*. **Broccoli:** blackleg. **Carrot:** Alternaria blight, black crown rot, no more than 4 applications. **Chinese mustard:** Alternaria leaf spot, no more than 4 applications. **Garlic:** white rot, no more than 1 application. **Lettuce:** lettuce drop, bottom rot, no more than 3 applications, 14 days.[a] **Onion** (dry bulb): Botrytis leaf blight, Botrytis neck rot, Alternaria purple blotch, no more than 5 applications. **Potato:** early blight, white mold, no more than 4 applications, 14 days.[a] The following crops may be rotated after harvest: **beans, broccoli, carrot, garlic, lettuce, onion** (dry bulb), **peanut, potato.** The following crops may be rotated 1 month following the last iprodione application: **cotton, root crops, tomato**. Read and follow label directions. **Cucurbits:** powdery mildew, gummy stem blight, 0 days.[a]
Kresoxim-methyl (Sovran)	**Cucurbits:** powdery mildew, gummy stem blight, 0 days.[a]

Table 2. Label information on fungicides and nematicides of less general use (cont.)

Fungicide	Crops and use restrictions
Mefenoxam	
(Apron XL LS)	**Beets, carrot, legume vegetables, okra, spinach:** seed treatment for control of *Pythium* and *Phytophthora* causing damping-off, seed rot, and systemic downy mildew diseases. Read and follow label directions for these uses, as well as seed treatments for export.
(Ridomil Gold Bravo)	**Broccoli, Brussels sprout, cabbage, cauliflower:** downy mildew, Alternaria leaf spot, 7 days.[a] Read and follow label directions. **Cucumber, melon, squash:** downy mildew, anthracnose, Cercospora leaf spot, gummy stem blight (black rot), leaf blight, scab. Read and follow label directions. **Onion**[c] (dry bulb, seed, green): downy mildew, Botrytis leaf blight (blast), purple blotch; dry, 7 days,[a] and green, 21 days.[a] Read and follow label directions. **Potato:** late blight, early blight, storage rots (Pythium leak; pink rot caused by *Phytophthora),* 14 days.[a] Read and follow label directions. **Tomato:** late blight, early blight, Phytophthora fruit rot, gray leaf spot, gray leaf mold, Septoria leaf spot, anthracnose, Alternaria fruit rot (black mold), Rhizoctonia fruit rot, Botrytis gray mold, 14 days.[a] Read and follow label directions.
(Ridomil Gold Copper)	**Carrot, radish:** diseases caused by oomycetes, 7 days.[a] Read and follow label directions. **Cucurbits:** downy mildew, 5 days.[a] Read and follow label directions. **Onion** (dry bulb, seed, green), **garlic:** downy mildew, dry, 10 days,[a] and green, 7 days.[a] Read and follow label directions. **Pepper:** Pythium damping-off, Phytophthora crown rot, 7 days.[a] Read and follow label directions. **Potato:** late blight, early blight, storage rots (Pythium leak; pink rot caused by *Phytophthora),* 7 days.[a] Read and follow label directions. **Spinach:** white rust, downy mildew, 21 days.[a] Read and follow label directions. **Tomato:** Phytophthora fruit rot, late blight, 14 days.[a] Read and follow label directions.
(Ridomil Gold EC)	**Asparagus:** Phytophthora crown and spear rot. Read and follow label directions. **Beans** (all), **lentils, peas, soybeans** (edible): Pythium damping-off and root rot. When applied preplant and incorporated in the top 2 in. of soil with a surface application, or in a 7-in. band at planting. Read and follow label directions. **Cole crops:** Pythium damping-off, Phytophthora basal stem rot. Surface applications may be broadcast at planting, incorporated into the upper 2 in. of soil. Seven-inch band applications are also labeled. Read and follow label directions. **Cucurbits:** Pythium damping-off, cottony leak. Applications may be in a 7-in. band over the row at planting or broadcast. Broadcast applications should be incorporated into the top 2 in. of soil. Read and follow label directions. **Eggplant, pepper:** Pythium damping-off, Phytophthora crown rot, 7 days.[a] **Lettuce** (head), **onion, spinach:** Pythium damping-off. Apply either broadcast or banded at planting. Read and follow label directions.

Table 2. Label information on fungicides and nematicides of less general use (cont.)

Fungicide	Crops and use restrictions
Mefenoxam (cont.)	
(Ridomil Gold EC)	**Root and tuber vegetables** (beet, carrot, radish, sweet potato): Read and follow label directions. **Tomato:** Pythium damping-off, as well as Pythium and Phytophthora fruit and root rots. Apply either broadcast or banded immediately before or after planting. Incorporate with irrigation. Read and follow label directions.
Ridomil Gold GR)	**Leafy vegetables** (excluding spinach), **lettuce** (head, leaf): Pythium damping-off. Applications may be made banded over the row or preplant incorporated. Read and follow label directions. **Spinach:** Pythium damping-off, white rust *(Albugo occidentalis),* downy mildew. Applications may be made preplant incorporated or preemergence. Read and follow label directions. **Tomato:** Pythium damping-off. Pythium and Phytophthora fruit and root rots, 7 days.[a] Read and follow label directions.
(Ridomil Gold MZ)	**Cucumber, melon, summer squash:** downy mildew, 5 days.[a] Read and follow label directions. **Onion** (dry bulb): downy mildew, 7 days.[a] Read and follow label directions. **Potato:** late blight, early blight, storage rots (Pythium leak; Phytophthora pink rot), 14 days.[a] Read and follow label directions. **Tomato:** late blight, 5 days.[a] Read and follow label directions.
(Ridomil Gold PC)	**Beans** (dry and green):[d] damping-off and seed and seedling rots caused by *Pythium* and *Rhizoctonia.* Apply 12 oz per 1,000 ft of row at planting time. Read and follow label directions.
Metalaxyl	
(Allegiance FL)	**Beets, carrot, cucumber, seed and pod vegetables, spinach, sweet corn, popcorn:** seed treatment for the control of Pythium damping-off and in certain crops for early-season *Phytophthora* control. Read and follow label directions for these uses, as well as seed treatments for export use.
Myclobutanil	
(Nova)	**Asparagus:** for control of rusts. Begin applying to developing ferns after harvest has taken place. Repeat application on a schedule that does not exceed 14-day intervals. Apply with a spray adjuvant. Do not spray within 180 days of harvest. **Beans** (snap): for control of rust and pot tip rot *(Rhizoctonia).* Begin application when rust is first observed; continue on a 7- to 10-day schedule, 0 days.[a] **Cucurbits:** for control of powdery mildew. Begin application at first sign of disease development and continue on a 7- to 10-day application schedule. Do not apply more than 1.5 lb product (0.6 lb active ingredient) per acre per crop per year. Application may be made up to and including the day of harvest. Read and follow label directions. **Tomato:** for control of powdery mildew. Begin application at the first sign of disease, and continue application on a schedule that does not exceed 21-day intervals, 0 days.[a] Read and follow label directions carefully.
Oxamyl	
(Vydate L)	**Carrot, cucurbits, eggplant, pepper, potato, sweet potato:** for nematode control. Apply before or at planting. Apply in transplant water for pepper or as foliar spray for pepper and vine crops, 7 days.[a] Read and follow label directions.

Table 2. Label information on fungicides and nematicides of less general use (cont.)

Fungicide	Crops and use restrictions
PCNB	
(Terraclor)	*Field use*—**Beans** (dry, snap, succulent): protective fungicide for control of root and stem rot caused by *Rhizoctonia solani*. Spray planting furrow and covering soil at planting. Apply only at planting time and avoid spraying directly on seed. Read and follow label directions. **Broccoli, Chinese broccoli, Brussels sprout, cabbage, Chinese cabbage** (tight-heading only), **cauliflower:** for control of clubroot and wirestem or black root. For effective control of clubroot, thoroughly mix Terraclor with the soil. Read and follow label directions. *Bedding plants*—**Beans, broccoli, Brussels sprout, cabbage, cauliflower, pepper, tomato:** soil drench to seedlings grown in containers or beds prior to transplanting for the control of root/stem rot and damping-off caused by *Rhizoctonia solani* and *Pellicularia filamentosa*. Read and follow label directions.
Phosphorous acid	
(Agri-Fos)	**Asparagus:** Phytophthora crown and spear rot, 0 days.[a] **Brassicas:** downy mildew, 0 days.[a] **Carrot:** Pythium and Phytophthora rot, 0 days.[a] **Cucurbits:** Phytophthora blight, gummy stem blight, downy mildew, 0 days.[a] **Eggplant:** gummy stem blight, Pythium rot, Phytophthora rot, 0 days.[a] **Ginseng:** Phytophthora root rot and foliar blight, 0 days.[a] **Leafy vegetables** (amaranth, arugula, cardoon, celery, chervil, corn salad, endive, fennel, parsley, radicchio, rhubarb, spinach, Swiss chard): downy mildew, 0 days.[a] **Legumes:** Pythium rot, Phytophthora rot, 0 days.[a] **Okra:** Pythium rot, Phytophthora blight, 0 days.[a] **Onion:** downy mildew, 0 days.[a] **Potato, sweet potato, yams:** pink rot *(Phytophthora* spp.), Pythium leak *(Pythium* spp.), late blight, 0 days.[a] **Tomato:** Late blight, 0 days.[a]
(Phostrol)	**Asparagus:** Phytophthora crown and spear rot, 0 days.[a] **Brassicas:** downy mildew, 0 days.[a] **Cucurbits:** downy mildew, Phytophthora blight, 0 days.[a] **Ginseng:** Phytophthora root rot and foliar blight, 0 days.[a] **Leafy vegetables** (except Brassica vegetables): downy mildew, 0 days.[a] **Onions** (dry bulb): downy mildew, 0 days.[a] **Peas:** downy mildew, Phytophthora disease, Pythium rot, 0 days.[a] **Potatoes:** pink rot *(Phytophthora* spp.) and Pythium leak *(Pythium* spp.), 0 days.[a] **Tomato:** Phytophthora root rot.
(ProPhyt)	**Brassicas:** downy mildew, 0 days.[a] **Cucurbits:** downy mildew, 0 days.[a] **Leafy vegetables** (lettuce, spinach): downy mildew, 0 days.[a] **Legume vegetables:** downy mildew, 0 days.[a] **Potato:** late blight, 0 days.[a] **Tomato, tomatillo:** late blight, 0 days.[a]

Table 2. Label information on fungicides and nematicides of less general use (cont.)

Fungicide	Crops and use restrictions
Propamocarb hydrochloride (Previcur Flex)	**Cucurbits:** for control of downy mildew. Begin foliar applications when conditions are favorable for disease development but before infection. Continue on 7- to 14-day intervals. Do not apply within 2 days of harvest. **Lettuce:** for control of downy mildew. Start applications before infection and continue on 7- to 10-day intervals. Do not apply within 2 days of harvest. **Peppers:** for control of *Pythium* spp. and *Phytophthora* spp. Read and follow label directions. **Potato:** for control of early blight and late blight. Do not apply within 14 days of harvest. **Tomatoes:** for control of late blight. Read and follow label directions. Do not apply within 5 days of harvest.
Propiconazole (Tilt)	**Celery:** early blight *(Cercospora),* late blight *(Septoria),* 14 days.[a] Read and follow label directions. **Corn** (sweet and pop): Helminthosporium leaf blights, rusts, gray leaf spot, eyespot. Sweet corn, 14 days.[a, b] Do not apply more than 16 fl oz per acre. Do not apply to popcorn after silking. Do not harvest for forage within 14 days of application for sweet corn or 30 days for popcorn. Read and follow label directions.
Prothioconazole (Proline 480SC)	**Chickpea:** Ascochyta blight, 7 days.[a] **Lentils:** Ascochyta blight, 7 days.[a]
Pyraclostrobin (Cabrio, Headline)	**Brassica head and stem** (broccoli, Brussels sprout, cabbage, Chinese cabbage, cauliflower, kohlrabi), **Brassica leafy green** (broccoli raab, Chinese cabbage, collard, kale, mustard green, rape green), **bulb vegetables** (garlic, leak, onion, shallot), **cucurbits** (chayote, Chinese waxgourd, citron melon, cucumber, gherkin, gourd, *Momordica* spp., muskmelon, pumpkin, summer squash, watermelon, winter squash), **fruiting vegetables** (eggplant, ground cherry, pepino, pepper, tomatillo, tomato), **leaf vegetables** (except Brassicas), leaves of root and tuber vegetables (except sugarbeet), **root vegetables** (black salsify, carrot, celeriac, chervil, chicory, edible burdock, garden beet, ginseng, horseradish, oriental radish, parsley, parsnip, radish, rutabaga, Spanish salsify, skirret, turnip), **tuber and corm vegetables** (arracacha, arrowroot, cassava, Chinese artichoke, chufa, dasheen, edible canna, Jerusalem artichoke, leren, potato, sweet potato, true yam, turmeric, yam bean).
(Pristine)	**Beans** (dry beans): Alternaria leaf and pod spot, anthracnose, Ascochyta blight, Botrytis gray mold, Cercospora leaf spot, downy mildew, Mycosphaerella blight, powdery mildew, rust, Septoria leaf spot, white mold, 21 days.[a] **Bulb vegetables** (garlic, leek, onion): Botrytis leaf blight, downy mildew, purple blotch, Stemphylium leaf blight and stalk rot, 7 days.[a] **Carrot:** Alternaria leaf spot, Cercospora leaf spot, powdery mildew, southern root rot *(Sclerotium rolfsii),* 0 days.[a]

Table 2. Label information on fungicides and nematicides of less general use (cont.)

Fungicide	Crops and use restrictions
Pyraclostrobin (cont.) (Pristine) (cont.)	**Cucurbits** (chayote, Chinese waxgourd, citron melon, cucumber, gherkin, gourds, *Momordica* spp., muskmelon, pumpkin, summer squash, winter squash): Alternaria blight, anthracnose, Cercospora leaf spot, downy mildew, gummy stem blight, powdery mildew, 0 days.[a]
Pyrimethanil (Scala SC)	**Bulb vegetables** (garlic, leek, onion, shallot): for control of Botrytis leaf blight and neck rot and purple blotch. Apply on 7- to 14-day intervals. Do not apply within 7 days of harvest. **Potato and other tuberous and corm vegetables** (arrachata, arrowroot, artichoke, canna, cassava, chayote, ginger, yam). Read and follow label directions. Do not apply within 7 days of harvest. **Tomatoes:** for control of early blight and gray mold. Apply on 7- to 14-day intervals. Do not apply within 1 day of harvest.
Streptomycin	**Beans:** halo blight, seed treatment. **Pepper, tomato:** apply at 2-leaf stage (200-ppm spray). **Potato:** seed-piece treatment only (100-ppm dip or dust). Soak cut seed pieces less than 30 min. Do not use treated seed for food or feed. Read and follow label directions.
Sulfur	Exempt when used with good agricultural practices. See label.
Terbufos (Counter 15G)	**Corn** (sweet and pop): apply in band or furrow at planting. Read and follow label directions.
Thiabendazole (Mertect 340F)	**Carrot:** storage rot (gray mold, white mold) control. **Sweet potato:** treatment of seed against black rot, scurf, and foot rot. Do not use treated roots for food or feed. **Potato:** seed-piece treatment to control Fusarium tuber rot. Do not treat seed potatoes after cutting. Read and follow label directions.
Thiophanate-methyl (Topsin M 70W, Topsin M WSB)	**Beans:** white mold, gray mold. Snap or dry beans, 14 days[a]; lima, 28 days.[a] **Cucurbits:** anthracnose, gummy stem blight, powdery mildew, target spot, 0 days.[a] **Onion:** white rot. Apply in-furrow at planting. Read and follow label directions.
Thiram	**Beans, beet, broccoli, Brussels sprout, cabbage, cantaloupe, carrot, castor beans, cauliflower, collard, corn** (sweet), **cucumber, eggplant, endive, kale, kohlrabi, lettuce, mustard, okra, onion, peas, pepper, pumpkin, radish, spinach, squash, Swiss chard, tomato, turnip, watermelon:** seed treatment. WARNING: Do not use treated seed for food, feed, or oil. **Onion:** furrow treatment. **Tomato:** for leaf spots and fruit rot, 0 days.[a] Read and follow label directions.

Table 2. Label information on fungicides and nematicides of less general use (cont.)

Fungicide	Crops and use restrictions
Trifloxystrobin (Flint)	**Cucurbits:** for control of downy mildew, powdery mildew, 0 days.[a] Follow label directions carefully. **Eggplant, groundcherry, pepino, pepper, tomatillo, tomato:** powdery mildew, early blight, gray leaf spot, late blight, 3 days.[a] Follow label directions.
(Gem)	**Potato:** early blight, late blight, 7 days.[a]
Triflumizole (Procure 50WS)	**Cucurbits** (cucumber, melons, summer squash, watermelon): for control of Alternaria leaf spot, Cercospora leaf spot, downy mildew, fruit and stem rot, 5 days.[a] Begin applications when plants are in the 2-leaf stage and repeat at 7- to 10-day intervals when environmental conditions are conducive for disease development.
Triphenyltin hydroxide (Super Tin)	**Potato:** for control of early blight and late blight, 3 days.[a] Begin applications at the first sign of disease or when late blight is reported in the area.
Vinclozolin (Ronilan)	**Beans** (snap, common, lima): gray mold, white mold, 14 days.[a] Do not make more than 2 applications per season or more than 2 lb of the product per season. Read and follow label directions. **Lettuce** (head or leaf): Sclerotinia drop, 28 days.[a] No more than 6 lb per acre per season. **Onion** (dry): white rot, Botrytis blight, neck rot, 18 days.[a] No more than 10 lb per acre per season.
Ziram (Ziram 76DF)	**Tomato** (not cherry tomato): anthracnose, early blight, Septoria leaf spot, 7 days.[a] Do not apply more than 24 lb of product per acre per crop cycle. Read and follow label directions.
Zoxamide (Gavel 75DF)	**Tomato** (not cherry tomato): anthracnose, early blight, Septoria leaf spot, 7 days.[a] Do not apply more than 24 lb of product per acre per crop cycle. Read and follow label directions. **Tomato:** for control of buckeye rot, early blight, gray leaf spot, late blight, leaf mold, Septoria leaf spot, bacterial speck, bacterial spot, 5 days.[a] Start applications when seedlings emerge or transplants are set and repeat at 7- to 10-day intervals. For bacterial diseases, use a full rate of fixed-copper fungicide in tank-mixed combinations with a full rate of Gavel 75DF. Follow label directions carefully.

[a]Number of days between last application and harvest.
[b]There are many other copper materials, but these are most widely available and labeled for use on vegetable crops. Exempt from tolerance if used with good agricultural practices; not exempt if used at the time of harvest or after harvest. See label.
[c]Phytotoxicity to crop or follow-up crop. See label.
[d]Do not feed treated tops or forage to livestock.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008

Vegetable and disease	Treatment	Remarks
ASPARAGUS		
Fusarium crown and root rot	Obtain crowns from a reliable source. Avoid fields with a history of crown and root rot. Avoid excessive cutting. Avoid acidic (low-pH) and poorly drained soils.	
	Mancozeb (e.g., Dithane and Penncozeb) are labeled for treating roots by dipping. Most dry formulations are labeled at 1 lb per 100 gal. water. Liquid formulations are mostly labeled at 0.8 qt per 100 gal. water.	
Phytophthora crown and spear rot	Agri-Fos at 1.25 to 2.5 qt per acre or Phostrol at 2 to 5 pt per acre.	Do not apply to ferns beginning to senesce.
	Aliette WDG at 5 lb per acre.	Apply once per season to fully expanded ferns. 110 days PHI.
	Ridomil Gold 4EC at 1 pt per acre over bed.	Apply 30 to 60 days before harvest. Make second application just before harvest. 1 day PHI.
Rust and Cercospora leaf spot	Chlorothalonil (e.g., Bravo, Echo, Equus) at 1.8 to 3.6 lb per acre for most dry formulations or 2 to 4 pt per acre for most flowable formulations.	Apply after harvest and at 14- to 28-day intervals. Protecting ferns during summer is essential for good yields. 190 days PHI.
	Mancozeb (e.g., Dithane, Penncozeb) at 2 lb per acre for dry formulations or 1.6 qt per acre for flowable formulations.	Begin applications to the developing ferns after harvest. Repeat on a schedule of less than 14 days. 180 days PHI.
BEANS (SNAP, DRY WAX, AND LIMA)		
Most diseases	When possible, use rotations of 2 to 3 years or longer between crops and practice strict sanitation.	
Seed decay, damping-off, seedborne stem blights	Plant only western-grown, certified pathogen-free seed in a seedbed that is warm (60° to 65°F), well prepared, and well drained. Treat seed with Allegiance FL, Apron XL plus thiram, captan, Dynasty, or Protégé and insecticide.	
Seedling diseases and root rots	Ridomil Gold EC at 0.5 to 1 pt per acre at planting, or Ridomil PC 11G at 0.75 lb per 1,000 ft of row at planting.	Applications may be made preplant incorporated, or as a soil-surface spray after planting.
Bacterial blights (brown spot, halo blight, common blight)	Plant only western-grown, certified pathogen-free seed. Utilize crop rotations of 2 to 3 years. Avoid cultivating when beans are wet.	
	Field applications of fixed copper fungicides. Applications rates vary widely with product and formulation.	Do not use copper on fresh-market lima bean.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
BEANS (SNAP, DRY WAX, AND LIMA) (CONT.)		
Rust, anthracnose (dry bean)	Follow 2- to 3-year rotation schedules.	Rotate with nonhost crops.
	Plant rust-resistant varieties.	Rust-resistant varieties are available.
	Amistar at 2.0 oz per acre for rust and 2.0 to 5.0 oz per acre for anthracnose.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 0 days PHI.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	Begin applications during early bloom or when disease threatens. 14 days PHI.
	Endura at 8 to 11 oz per acre.	Rust only. Apply at beginning of flowering or prior to onset of disease. Make second application at full bloom if necessary. 21 days PHI.
	Headline at 6.9 oz per acre.	Begin applications at the beginning of flowering. Do not make more than 2 applications of Headline or other group II fungicides per year. 21 days PHI.
	Manex at 1.2 to 1.6 qt per acre or Maneb 15DF or Maneb 80WP at 2.0 lb per acre.	Spray on a 7-day interval. 30 days PHI.
	Quadris at 6.0 fl oz per acre for rust and 6.0 to 15.5 fl oz per acre for anthracnose.	Do not make more than 2 applications before alternating to a fungicide with a different mode of action. 0 days PHI.
	Quadris Opti at 1.6 to 2.4 pt per acre.	Do not make more than 2 applications of Quadris Opti before alternating to a non-group-II fungicide. 14 days PHI.
	Topsin 70WP at 1 to 2 lb per acre. Topsin 4.5L at 30 to 40 fl oz per acre if 1 application and 20 to 30 fl oz if 2 applications are made.	Anthracnose only. Apply once if applied at 50 to 70% full bloom. Apply twice if first application is at 10 to 30% full bloom and second application is 4 to 7 days later (peak bloom). 28 days PHI.
Rust (snap bean)	Follow 2- to 3-year rotation schedules.	Rotate with nonhost crops.
	Rust-resistant varieties are available.	Several races of the pathogen are known.
	Amistar at 2.0 oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 0 days PHI.
	Endura at 8 to 11 oz per acre.	Apply at beginning of flowering or prior to onset of disease. Make second application at full bloom if necessary. 7 days PHI.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
BEANS (SNAP, DRY WAX, AND LIMA) (CONT.)		
Rust (snap bean) (cont.)	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	Begin applications at first sign of disease. 7 days PHI.
	Headline at 6 to 9 oz per acre.	Begin applications at the beginning of flowering. Do not make more than 2 applications of Headline or other group II fungicides per year. 7 days PHI.
	Nova 40W at 4 to 5 oz per acre.	0 days PHI.
	Quadris at 6.0 fl oz per acre.	Do not make more than 2 applications before alternating to a fungicide with a different mode of action. 0 days PHI.
Asian soybean rust	Headline at 6.0 to 9.0 fl oz per acre mixed with an adjuvant and a non-group-II fungicide.	Snap bean, dry bean, and lima bean do not appear to be very susceptible to Asian soybean rust. However, growers should monitor the epidemics and scout fields. 21 days PHI.
	Amistar at 2.0 to 5.0 oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 0 days PHI.
White mold and gray mold	Avoid fields with history of white mold or with poor drainage.	
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	Gray mold on snap bean only. Apply at weekly intervals. 7 days PHI.
	Endura 70WG at 8 to 11 oz per acre.	See remarks for Endura under rust. 7 days PHI for snap bean. 21 days PHI for lima and dry beans.
	Rovral 75WG at 1.0 to 1.33 lb per acre for flowable formulations.	Apply at first bloom and again at full bloom. Do not apply after full bloom. Observe restrictions on feeding of forage. 0 days PHI.
	Switch at 11 to 14 oz per acre.	Do not make more than 2 applications before alternating to a fungicide with a different mode of action. 7 days PHI.
	Topsin 70WP at 1 to 2 lb per acre. Topsin 4.5L at 30 to 40 fl oz per acre if 1 application and 20 to 30 fl oz if 2 applications are made.	Apply once if applied at 50 to 70% full bloom. Apply twice if first application is at 10 to 30% full bloom and second application 4 to 7 days later (peak bloom). 14 days PHI for dry, snap, and lima beans.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
BEANS (SNAP, DRY WAX, AND LIMA) (CONT.)		
Soybean cyst nematode	Rotate at least 2 to 3 years with corn, small grains, alfalfa, or other nonhost crops.	Do not include soybeans in the rotation.
Mosaic virus diseases	Plant varieties with resistance to common mosaic, NY 15 strain of common mosaic, and bean yellow mosaic.	Bush Blue Lake 274, Cherokee, Goldcup, Provider, Tendercrop.
BEET (GARDEN), SWISS CHARD		
Seed rot, damping-off, seedborne leaf spot	Sow seed in a well-prepared seedbed. Treat seed with Apron XL or Allegiance FL (for *Pythium*), captan, or thiram. Make sure boron levels are adequate.	Several soluble boron formulations are available.
Cercospora leaf spot	Amistar at 3.0 to 5.0 oz per acre.	Do not make more than 2 applications before alternating to a fungicide with a different mode of action. 0 days PHI.
	Cabrio at 8 to 12 oz per acre.	Do not make more than 2 applications before alternating to a fungicide with a different mode of action. 0 days PHI.
	Quadris at 9.2 to 15.4 fl oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 0 days PHI.
	Switch at 11 to 14 oz per acre.	Do not make more than 2 applications before alternating to a fungicide with a different mode of action. 7 days PHI.
CARROT, PARSNIP		
Seed rot, damping-off	Treat seed with captan or thiram. Plant in a well-drained seedbed. Avoid overwatering. Apron XL and Allegiance FL can be used to control Pythium damping-off on carrot.	
Cercospora leaf spot, Alternaria leaf blight	Use 3- to 4-year crop rotations. Amistar at 2 to 5 oz per acre for Alternaria diseases and 3 to 5 oz per acre for Cercospora leaf spot. Carrot: 3 to 5 oz per acre for both diseases.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 0 days PHI.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
CARROT, PARSNIP (CONT.)		
Cercospora leaf spot, Alternaria leaf blight (cont.)	Cabrio at 8 to 12 oz per acre.	Do not make more than 2 applications before alternating to a fungicide with a different mode of action. 0 days PHI.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	0 days PHI for carrot. 10 days PHI for parsnip.
	Endura at 4.5 oz per acre.	Carrot only. Apply no more than twice before alternating to a fungicide with a different mode of action. 0 days PHI.
	Pristine at 8 to 10.5 oz per acre.	Carrot only. Apply no more than twice before alternating to a fungicide with a different mode of action. 0 days PHI.
	Quadris at 6.0 to 15.5 fl oz per acre for Alternaria diseases and 9.2 to 15.4 fl oz per acre for Cercospora leaf spot. Carrot: 9.0 to 15.5 fl oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 0 days PHI.
	Quadris Opti at 2.4 pt per acre.	Carrot only. Do not make more than 1 application of Quadris Opti before alternating to a non-group-II fungicide. 0 days PHI.
	Rovral at 1 to 2 pt per acre for flowable (F) formulations or ⅓ to 1⅓ lb per acre for dry formulations.	Alternaria leaf blight on carrot only. When tank-mixed with another fungicide registered for use on carrot, use low rate. 0 days PHI.
	Switch at 11 to 14 oz per acre.	Do not make more than 2 applications before alternating to a fungicide with a different mode of action. 7 days PHI.
Powdery mildew	Pristine at 8 to 12 oz per acre.	See remarks on Cercospora leaf spot.
White mold	Use a crop rotation of 3 to 4 years.	
Aster yellow	Use an insecticide to control leafhoppers that transmit the disease.	Effective early-season leafhopper control is essential. Control must occur before leafhoppers feed.
Root-knot nematode	Methyl bromide or sodium methyl dithiocarbamate or Vydate L.	Carrot only. Sample fields for plant parasitic nematodes before planting. Methyl bromide and sodium methyl dithiocarbamate give best results when nematode populations are moderate to high. Vydate gives adequate control when populations are low to moderate.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
CELERY, PARSLEY		
Seed rot, damping-off	Conditions that favor rapid seed germination limit damping-off severity.	Avoid excessive irrigation and poorly drained soils.
	Treat seeds with hot water, then captan and thiram.	
	Ridomil Gold EC at 1 to 2 pt per acre applied preplant to control damping off.	Apply preplant to the soil surface and incorporate to a depth of 2 inches. 21 days PHI.
Leaf blights and spots **(celery only)**	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	Follow the label directions. 7 days PHI.
	Amistar at 3 to 5 oz per acre or Quadris at 9.0 to 15.5 fl oz per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. 0 days PHI.
	Quadris Opti at 2.4 to 3.7 pt per acre.	Do not make more than 2 foliar applications before alternating to a fungicide with different mode of action. 7 days PHI.
	Switch at 11 to 14 oz per acre.	After two applications of Switch, alternate with another fungicide with a different mode of action. 0 days PHI.
Powdery mildew	Amistar at 4 to 5 oz per acre or Quadris at 12 to 15.5 fl oz per acre.	Do not make more than 2 applications of either Amistar or Quadris before alternating to a fungicide with a different mode of action. 0 days PHI.
CRUCIFER CROPS: BROCCOLI, BRUSSELS SPROUT, CABBAGE, CAULIFLOWER, CHINESE CABBAGE, COLLARD, KALE, KOHLRABI, MUSTARD, RADISH, RUTABAGA		
Seed rot, damping-off	Plant only western-grown, hot water–treated seed. Apply thiram or captan after hot water treatment.	
	4-year or longer crop rotation.	Rotate to noncruciferous crops.
	Ridomil Gold EC at 1 to 2 pt per acre for Pythium damping-off and basal stem rot caused by *Phytophthora* spp.	Preplant incorporation into soil or soil-surface application at planting.
Alternaria leaf spot	3- to 4-year crop rotation.	Rotate to noncruciferous crops.
	Amistar at 2 to 5 oz per acre or Quadris at 6.2 to 15.4 fl oz per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. 0 days PHI.
	Cabrio at 12 to 16 oz per acre.	3 days PHI for collard, kale, and mustard. 0 days PHI for others.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
CRUCIFER CROPS: BROCCOLI, BRUSSELS SPROUT, CABBAGE, CAULIFLOWER, CHINESE CABBAGE, COLLARD, KALE, KOHLRABI, MUSTARD, RADISH, RUTABAGA (CONT.)		
Alternaria leaf spot (cont.)	Chlorothalonil (e.g., Bravo, Echo, Equus) at 1.4 lb per acre for dry formulations and 1.5 pt per acre for flowable formulations. **Not for use on collard, kale, or mustard.**	Not for use on collard, kale, or mustard. 7 days PHI.
	Copper compounds at various rates.	0 days PHI.
	Endura at 6 to 9 oz per acre.	14 days PHI for collard, kale, and mustard. 0 days PHI for all others.
	Maneb (e.g., Maneb, Manex) at various rates, depending on crop and formulation.	10 days PHI for kale. 14 days PHI for collard, mustard, and turnip greens. 7 days PHI for all others.
Black leg	3- to 4-year crop rotation.	Rotate to noncruciferous crops.
	Plant disease-free seeds or seedlings.	Hot-water seed treatment helps to eliminate seedborne pathogens.
	Cabrio at 12 to 16 oz per acre.	0 days PHI.
	Rovral at 2 pt per acre for flowable formulations or 2 lb per acre for dry formulations.	Broccoli only. Apply at 2- to 4-leaf stage. 0 days PHI.
Black rot	3- to 4-year crop rotation.	Rotate to noncruuciferous crops.
	Plant pathogen-free seeds or transplants.	Hot-water seed treatment helps to eliminate soilborne pathogen.
	Plant disease-resistant cabbage varieties.	Several varieties with partial resistance are available.
	Actigard at 1 oz per acre. Suppression only.	Do not apply to plants stressed by drought, herbicide injury, or other factors. 0 days PHI.
	Fixed-copper formulations at various rates.	Read and follow label directions. 0 days PHI.
Club root	Plant disease-free transplants.	Club root may be carried in transplants.
	7-year or longer crop rotation.	Rotate to noncruciferous crops.
	Improve soil conditions.	Avoid poorly drained soils with a history of club root. Crop losses can be avoided by raising the pH to 7.2 to 7.5.
	Terrachlor at various rates. Mix terrachlor with soil.	Transplants: Mix 3 pt in 100 gal. of water and use 0.5 pt per plant. Band applications: 5 to 6 gal. per acre in 25 gal. water, or 55 fl oz per 1,000 ft of row. Broadcast applications: 7.5 gal. in 30 gal. of water.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
CRUCIFER CROPS: BROCCOLI, BRUSSELS SPROUT, CABBAGE, CAULIFLOWER, CHINESE CABBAGE, COLLARD, KALE, KOHLRABI, MUSTARD, RADISH, RUTABAGA (CONT.)		
Downy mildew	3- to 4-year crop rotation.	Rotate to noncruciferous crops.
	Plant disease-resistant broccoli varieties.	Several resistant varieties are available.
	Acrobat at 6.4 oz per acre or Forum at 6 fl oz per acre. Suppression only.	Tank-mix with another fungicide. Do not make more than 2 sequential applications. 0 days PHI.
	Aliette at 2 to 5 lb, Agri-Fos at 1.25 to 2.5 qt, Phostrol at 2.5 to 5.0 pt, or ProPhyt at 2 to 4 pt per acre.	Read and follow label directions.
	Amistar at 2 to 5 oz per acre or Quadris at 6.2 to 15.4 fl oz per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. 0 days PHI.
	Cabrio at 12 to 16 oz per acre.	3 days PHI for collard, kale, and mustard; 0 days PHI for all others.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	Not for use on collard, kale, mustard, or turnip greens. 7 days PHI.
	Ridomil Gold Bravo at 1.5 lb per acre.	Not for use on collard, kale, mustard, or turnip greens. 7 day PHI.
Fusarium yellows	Plant Fusarium-yellow-resistant varieties.	Many resistant varieties are available.
Powdery mildew	Cabrio at 12 to 16 oz per acre.	3 days PHI for collard, kale, and mustard; 0 days PHI for all others.
	Endura at 6 to 9 oz per acre.	Not for turnip greens. No more than 2 applications. 0 days PHI for broccoli, Brussels sprout, cabbage, and cauliflower. 14 days PHI for all others.
	Microthiol Special at 3 to 10 lb per acre.	Apply at early leaf stage. Repeat applications every 10 to 14 days or as needed.
Rhizoctonia bottom rot	Cabrio at 12 to 16 oz per acre.	Not for turnip greens. 3 days PHI for collard, kale, and mustard. 0 day PHI for all others.
	Endura at 6 to 9 oz per acre. Suppression only.	See remarks on powdery mildew.
Sclerotinia stem rot	Endura at 6 to 9 oz per acre.	See remarks on powdery mildew.
White rust	Amistar at 2 to 5 oz per acre or Quadris at 6.0 to 15.5 fl oz per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. 0 days PHI.
	Cabrio at 12 to 16 oz per acre.	Do not make more than 2 applications before alternating to a fungicide with a different mode of action. 0 days PHI.
Wirestem	Terrachlor at various rates.	See remarks on club root.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
CUCURBITS: CUCUMBER, MUSKMELON OR CANTALOUPE, PUMPKIN, SQUASH, WATERMELON		
General recommendations	Use a crop rotation of 3 to 4 years. Grow resistant varieties wherever possible.	Rotation with noncucurbit crops.
Seed rot, damping-off, seedborne diseases	Plant only certified, western-grown seed treated with thiram or captan.	
	Seed treatment with Apron XL LS at 0.64 fl oz per 100 lb seed.	Apron XL LS can prevent seed rot and damping-off up to 5 weeks.
	Ridomil Gold EC at 1 to 2 pt per acre.	Can be applied as a broadcast or banded at planting.
Alternaria leaf blight	3- to 4-year crop rotation.	Rotate with noncucurbit crops.
	Amistar at 3.5 to 5.0 oz, Quadris at 11.0 to 15.4 fl oz, or Quadris Opti at 3.2 pt per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. 1 day PHI for all three fungicides.
	Cabrio at 12 to 16 oz per acre or Pristine at 12.5 to 18.5 oz per acre.	Do not apply Cabrio or Pristine more than once before alternating to a fungicide with a different mode of action. 0 days PHI for both fungicides.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	0 days PHI.
	Gavel at 1.5 to 2.0 lb per acre.	See label detail for crops. 5 days PHI.
	Mancozeb (e.g., Dithane, penncozeb) at various rates.	See label detail for crops. 5 days PHI.
	Maneb (e.g., Maneb, Manex) at various rates.	5 days PHI.
	Reason at 5.5 fl oz per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. Read and follow label directions. 14 days PHI.
	Tanos at 8 oz per acre.	Mix with a contact fungicide with a different mode of action. 3 days PHI.
Angular leaf spot (cucumber, muskmelon, watermelon)	Plant resistant varieties.	Several resistant varieties of cucumber are available.
	Copper fungicides.	Read and follow label directions.
Anthracnose (cucumber, muskmelon, watermelon)	Plant resistant varieties.	Resistant varieties of cucumber are available.
	3- to 4-year crop rotation.	Rotate with noncucurbit crops.
	Amistar at 3.5 to 5.0 oz, Quadris at 11.0 to 15.4 fl oz, or Quadris Opti at 3.2 pt per acre.	See remarks on Alternaria leaf blight.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
CUCURBITS: CUCUMBER, MUSKMELON OR CANTALOUPE, PUMPKIN, SQUASH, WATERMELON (CONT.)		
Anthracnose (cucumber, muskmelon, watermelon) (cont.)	Cabrio at 12 to 16 oz or Pristine at 18.5 oz per acre.	See remarks on Alternaria leaf blight. 0 days PHI.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	0 days PHI.
	Mancozeb (e.g., Dithane, Penncozeb) at various rates.	See label detail on crops. 5 days PHI.
	Tanos at 8.0 oz per acre.	See remarks on Alternaria leaf blight.
Bacterial fruit blotch (primarily muskmelon and watermelon)	Plant uncontaminated seed.	The pathogen is primarily seedborne.
	Sanitize the greenhouse thoroughly.	The pathogen can survive in greenhouses.
	Plow contaminated fields in fall.	Fall plowing minimizes pathogen survival.
	2-year crop rotation.	Rotate with noncucurbit crops.
	Apply copper fungicides.	Copper may reduce disease severity.
	Tanos at 8 to 10 oz per acre. Disease suppression only.	See remarks on Alternaria leaf blight.
Bacterial leaf and fruit spot	2-year crop rotation.	Rotate with noncucurbit crops.
	Plant pathogen-free seed.	The pathogen is seedborne.
	Weekly application of copper fungicides.	Begin application when fruits are 4 inches in diameter.
Bacterial wilt	Apply insecticides to control cucurbit beetles.	Disease control depends on control of striped and spotted cucumber beetles. Apply insecticide only when beetles are present.
Downy mildew	Plant resistant varieties.	Several cucumber varieties are resistant.
	Acrobat at 6.4 oz per acre or Forum at 6 fl oz per acre.	Acrobat or Forum must be applied as a tank mix with a fungicide active against downy mildew. Do not make more than 2 applications before alternating to a fungicide with a different mode of action. 0 days PHI.
	Agri-Fos at 1.25 pt, Phostrol at 2.5 to 5.0 pt, or ProPhyt at 2 to 4 pt per acre.	0 days PHI.
	Aliette at 2 to 5 lb per acre. Use 2 to 3 lb when tank-mixed with another fungicide. Use 3 to 5 lb when used alone.	3 days PHI.
	Amistar at 3.5 to 5.0 oz, Quadris at 11 to 15.5 fl oz, or Qudris Opti at 3.2 pt per acre.	See remarks on Alternaria leaf spot. 1 day PHI for all three fungicides.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
CUCURBITS: CUCUMBER, MUSKMELON OR CANTALOUPE, PUMPKIN, SQUASH, WATERMELON (CONT.)		
Downy mildew (cont.)	Cabrio at 8 to 12 oz per acre or Pristine at 12.5 to 18.5 oz per acre.	Begin applications before disease development. 0 days PHI.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	0 days PHI.
	Curzate at 3.2 oz per acre.	Use in combination with a labeled fungicide (e.g., copper, mancozeb, or chlorothalonil).
	Flint at 4.0 oz per acre.	Do not apply Flint more than once before alternating to a fungicide with a different mode of action. 0 days PHI.
	Maneb (e.g., Maneb, Manex) at various rates.	5 days PHI.
	Mancozeb (e.g., Dithane, Manzate, Penncozeb) at various rates.	5 days PHI.
	Previcur Flex at 1.2 pt per acre.	2 days PHI.
	Ranman at 2.1 to 2.75 fl oz per acre.	Alternate with a fungicide with a different mode of action. 0 days PHI.
	Reason at 5.5 fl oz per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. Read the label and follow the directions. 14 days PHI.
	Ridomil Gold Bravo at 2 lb per acre. Ridomil Gold MZ at 1.5 to 2.0 lb per acre dry or 2.5 pt per acre flowable.	Do not use Ridomil Gold MZ with pumpkin. 0 days PHI for Ridomil Gold Bravo. 5 days PHI for Ridomil Gold MZ.
	Tanos at 8 oz per acre.	See remarks for Tanos on Alternaria leaf blight. 3 days PHI.
Fusarium fruit rot	Long rotations of noncucurbit crops. Avoid field with a history of the Fusarium problem.	No resistant varieties are available. Fusarium fruit rot is often observed in the fields where other diseases are present.
Fusarium wilt (muskmelon)	Plant resistant muskmelon varieties.	Several resistant varieties are available.
Fusarium wilt (watermelon)	Plant watermelon varieties with resistance.	Rotation with noncucurbit crops will decrease incidence of the wilt.
Gummy stem blight/black rot	3- to 4-year crop rotation.	Rotate with noncucurbit crops.
	Agri-Fos at 1.25 qt per acre.	0 days PHI.
	Amistar at 3.5 to 5.0 oz per acre, Quadris at 11.0 to 15.5 fl oz per acre, or Quadris Opti at 3.2 pt per acre.	See remarks on Alternaria leaf blight. 1 day PHI.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
CUCURBITS: CUCUMBER, MUSKMELON OR CANTALOUPE, PUMPKIN, SQUASH, WATERMELON (CONT.)		
Gummy stem blight/black rot (cont.)	Cabrio at 12 to 16 oz per acre.	Begin application before disease development. See remarks on Alternaria leaf blight. 0 days PHI.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	0 days PHI.
	Mancozeb (e.g., Dithane, Penncozeb) at various rates.	Do not apply mancozeb products to pumpkins. 5 days PHI.
	Pristine at 12.5 to 18.5 oz per acre.	See remarks on Alternaria leaf blight. 0 days PHI.
Nematodes (muskmelons and watermelons)	Methyl bromide. Sodium methyl dithiocarbamate. Telon II or Telon C-35 Vydate L.	Methyl bromide or sodium methyl dithiocarbamate gives best results when nematode populations are moderate to high. Vydate is used when nematode populations are low to moderate.
Phytophthora and Pythium fruit and root rot, foliar blight	3-year or longer crop rotation. Avoid fields with a history of the diseases on cucurbits, eggplants, peppers, and tomatoes.	No resistant variety is available.
	Acrobat at 6.4 oz per acre or Forum at 6.0 fl oz per acre.	See remarks on downy mildew. 0 days PHI.
	Apron XL LS at 6.4 fl oz per 100 lb seed.	Only for direct-seeded plants.
	Ranman at 2.75 fl oz per acre.	Alternate application of Ranman with a fungicide with a different mode of action. 0 days PHI.
Plectosporium blight (pumpkin and squash)	3- to 4-year crop rotation. Management activities that control black rot should also control Plectosporium blight.	Rotate with noncucurbit crops.
	Cabrio at 12 to 16 oz per acre.	Follow label directions. 0 days PHI.
	Flint at 1.5 to 2.0 oz per acre.	See remarks on downy mildew.
Powdery mildew	Plant resistant varieties wherever possible.	Watermelons are generally unaffected. Partially resistant cucumber, muskmelon, and pumpkin varieties are available.
	Amistar at 3.5 to 5.0 oz per acre.	See remarks on Alternaria leaf blight. 1 day PHI.
	Quadris at 11.0 to 15.5 fl oz per acre. Quadris Opti at 3.2 pt per acre.	
	Cabrio at 12 to 16 oz per acre.	See remarks on Alternaria leaf blight. 0 days PHI.
	Flint at 1.5 to 2.0 oz per acre.	See remarks on downy mildew. 0 days PHI.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
CUCURBITS: CUCUMBER, MUSKMELON OR CANTALOUPE, PUMPKIN, SQUASH, WATERMELON (CONT.)		
Powdery mildew (cont.)	Nova at 2.5 to 5.0 oz per acre.	0 days PHI.
	Pristine at 12.5 to 18.5 oz per acre.	See remarks on Alternaria leaf blight. 0 days PHI.
	Topsin M 70WP at 0.5 lb per acre or Topsin 4.5 FL at 10 fl oz per acre.	1 day PHI.
Scab (cucumber)	Plant resistant varieties.	Several cucumber varieties are resistant to scab.
	3- to 4-year crop rotation.	
	Amistar at 3.5 to 5.0 oz per acre.	See remarks on Alternaria leaf blight. 1 day PHI.
	Quadris at 11.0 to 15.5 fl oz per acre.	
	Chlorothalonil (e.g., Bravo, Echo) at various rates.	0 days PHI.
	Mancozeb (e.g., Dithane, Penncozeb) at labeled rates.	5 days PHI.
Virus diseases	Control insect vectors. For squash mosaic virus, plant virus-free seed.	Most viruses are transmitted by aphids. Insect control, however, will not effectively reduce virus incidence in late-season crops. Early planting will reduce virus infection.
EGGPLANT		
Seed rot, damping-off, and seedling diseases	Plant hot water–treated seed. Treat the seed with captan or thiram.	
	Avoid fields with a history of Verticillium wilt.	
Verticillium wilt	Crop rotation with small grains.	Long rotations out of solanaceous crops.
	Fumigation with Vapam (37.5 to 75.0 gal. per acre) under plastic mulch.	Allow at least 21 days between application of fumigant and transplanting.
HORSERADISH		
Leaf spots *(Alternaria and Cercospora)*	2-year crop rotation.	Rotate with nonhost crops.
	Amistar at 2 to 5 oz per acre.	Do not apply more than once before application of a fungicide with a different mode of action. 0 days PHI.
	Quadris at 6.0 to 15.5 fl oz per acre.	
	Cabrio at 8 to 12 oz per acre.	Do not make 2 sequential applications before alternating to a fungicide with a different mode of action. 0 days PHI.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
HORSERADISH (CONT.)		
White rust	Amistar at 2 to 5 oz per acre.	See remarks on leaf spots. 0 days PHI.
	Quadris 6.0 to 15.5 fl oz per acre.	
	Cabrio at 8 to 16 oz per acre.	See remarks on leaf spots. 0 days PHI.
Bitter rot	Control leafhoppers that spread the disease agent.	Use insecticides.
Turnip mosaic virus	Plant virus-free rootstocks.	
LETTUCE, ENDIVE		
Seed rot, damping-off	Conditions that favor rapid germination limit damping-off.	Avoid excessive irrigation and poorly drained soils.
	Previcur Flex at various rates for leaf lettuce before or after transplanting in greenhouse.	Follow label directions. 2 days PHI.
	Ridomil Gold EC at 1 to 2 pt per acre.	Apply preplant to the soil surface and incorporate. 21 days PHI.
Downy mildew	Plant downy mildew–resistant varieties.	
	Acrobat at 6.4 oz per acre or Forum at 6.0 fl oz per acre.	0 days PHI.
	Agri-Fos at 2 qt per acre or Phostrol at 2.5 to 5.0 pt per acre.	0 days PHI.
	Aliette at 3 to 5 lb per acre (alone) or 2 to 3 lb per acre when tank-mixed with another fungicide.	3 days PHI.
	Amistar at 4 to 5 lb per acre or Quadris at 12.0 to 15.5 fl oz per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. 0 days PHI.
	Copper sulfate at various rates.	Follow label directions.
	Previcur Flex at 2 pt per acre.	2 days PHI.
	Reason at 5.5 to 8.2 oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. Follow label directions. 2 days PHI.
	Tanos at 8 oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action.
Powdery mildew	Amistar at 4 to 5 oz per acre or Quadris at 12.3 to 15.4 fl oz per acre.	See remarks on downy mildew. 0 days PHI.
	Switch at 10 to 12 oz per acre.	Do not make more than 2 applications before alternating to a fungicide with a different mode of action. 7 days PHI.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
LETTUCE, ENDIVE (CONT.)		
Rhizoctonia bottom rot, Sclerotinia drop	Avoid fields with poorly drained soils and a history of the disease.	
	Amistar at 0.125 to 0.25 oz per 1,000 row ft or Quadris at 0.40 to 0.80 fl oz per 1,000 row ft.	Follow the directions on the labels. 0 days PHI.
	Endura at 8 to 11 oz per acre.	Do not make more than 2 sequential applications before alternating to a fungicide with a different mode of action. 14 days PHI.
	Rovral at 1.5 to 2.0 pt per acre for flowable or 1.0 to 1.3 lb per acre for Rovral 75WP.	Follow label directions. 14 days PHI.
MINT (PEPPERMINT AND SPEARMINT)		
Powdery mildew	Amistar at 2 to 5 oz per acre. Quadris at 6.0 to 15.5 fl oz per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. 0 days PHI for fresh mint. 7 days PHI for processing mint.
Rust, Septoria leaf spot	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	Follow label directions. 80 days PHI.
	Nova at 4 to 5 oz per acre.	For rust only. 30 days PHI.
Verticillium wilt	Use wilt-resistant varieties of peppermint. Rotate plantings after no more than 3 to 4 years.	
OKRA		
Fusarium wilt	Avoid fields with a history of Fusarium wilt.	
	Crop rotation of several years may reduce Fusarium wilt severity.	Plant field to nonhost crops.
ONION, GARLIC, LEEK, CHIVE, SHALLOT		
Alternaria purple blotch and Botrytis leaf blight (all types)	3- to 4-year crop rotation.	Rotation out of onions or related vegetables.
	Amistar at 2 to 4 oz per acre for purple blotch and 3 to 5 oz per acre for Botrytis leaf blight. Quadris at 6.0 to 12.0 fl oz per acre for purple blotch and 9.0 to 15.5 fl oz per acre for Botrytis leaf blight.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 0 days PHI.
	Cabrio at 8 to 12 oz per acre for purple blotch and 12 oz per acre for Botrytis leaf blight.	Do not apply Cabrio more than twice before alternating to a fungicide with a different mode of action. 7 days PHI.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	7 days PHI.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
ONION, GARLIC, LEEK, CHIVE, SHALLOT		
Alternaria purple blotch and Botrytis leaf blight (all types) (cont.)	Endura at 6.8 oz per acre.	Do not make more than 2 applications before alternating to a fungicide with a different mode of action. 7 days PHI.
	Maneb at 2 to 3 lb per acre or Manex at 1.6 to 2.4 qt per acre.	7 days PHI.
	Pristine at 10.5 to 18.5 oz per acre for purple blotch and 14.5 to 18.5 oz for Botrytis leaf blight.	Do not make more than 2 applications before alternating to a fungicide with a different mode of action.
	Quadris Opti at 1.6 to 3.2 pt per acre.	Purple blotch only. Do not apply more than once before alternating to a fungicide with a different mode of action. 0 days PHI.
	Reason at 5.5 fl oz per acre.	Purple blotch only. Do not apply more than once before alternating to a fungicide with a different mode of action. 7 days PHI.
	Scala at 18 oz per acre (9 oz per acre in tank mixes.)	Tank mixes should include broad-spectrum fungicides. 7 days PHI.
	Switch at 11 to 14 oz per acre.	7 days PHI.
Alternaria purple blotch and Botrytis leaf blight (dry bulb, garlic only)	Aliette at 2 to 3 lb per acre.	Purple blotch only. 7 days PHI.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	7 days PHI.
	Mancozeb (e.g., Dithane, Manzate, Manex II, Penncozeb) or maneb (e.g., Maneb, Manex) at various rates.	Mancozeb is not labeled for use on pumpkin. 7 days PHI.
	Rovral at 1.0 to 1.5 pt per acre or Rovral WG at ⅔ to 1.0 lb per acre.	7 days PHI.
Botrytis neck rot	Wind-row plants until neck tissues are dry before storage.	Artificially drying may be necessary (forced heated air at 93° to 95°F for 5 days).
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	7 days PHI.
	Maneb 75DF or Maneb 80WP at 2 to 3 lb per acre or Manex at 1.6 to 2.4 qt per acre.	7 days PHI.
Downy mildew	Acrobat at 6.4 oz per acre or Forum at 6.0 fl oz per acre.	Do not apply more than twice before alternating to a fungicide with a different mode of action. 0 days PHI.
	Agri-Fos at 1.25 qt per acre.	7 days PHI.
	Aliette at 2 to 3 lb per acre.	7 days PHI.
	Amistar at 3 to 5 oz per acre or Quadris at 9.0 to 15.5 fl oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 7 days PHI.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
ONION, GARLIC, LEEK, CHIVE, SHALLOT		
Downy mildew (cont.)	Cabrio at 12 oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 7 days PHI.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	7 days PHI.
	Mancozeb (e.g., Dithane, Manzate, Manex II, Penncozeb) or maneb (e.g., Manex, Maneb) at various formulations and rates.	7 days PHI.
	Maneb at 2 to 3 lb per acre or Manex at 1.6 to 2.4 qt per acre.	7 days PHI.
	Phostrol at 2.5 to 3.75 pt per acre.	0 days PHI.
	Pristine at 18.5 oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 7 days PHI.
	Quadris Opti at 2.4 to 3.7 pt per acre.	Green bunching onions and leeks only. Do not make more than 1 application before alternating to a fungicide in group II. 14 days PHI.
	Reason at 5.5 fl oz per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. 7 days PHI.
	Ridomil Gold Bravo at 2.0 lb per acre.	7 days PHI.
	Ridomil Gold MZ at 2.5 lb per acre.	5 days PHI.
Fusarium basal rot	Plant Fusarium-resistant varieties.	Elba Globe, Spartan Banner, and Harvestmore are resistant.
PEAS		
Seed rot and seedling damping-off	Plant western-grown seed treated with captan, Dynasty, or thiram and Apron XL LS.	Apply seed treatment just before planting. Follow label directions.
Ascochyta blight	Use pathogen-free seed and a 3-year crop rotation.	Rotate with nonhost crops.
	Amistar at 2 to 5 oz per acre or Quadris at 6.0 to 15.0 fl oz per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. 0 days PHI.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	14 days PHI.
	Proline at 4.3 to 5.7 fl oz per acre.	For chickpea. 7 days PHI.
	Quadris Opti at 1.6 to 2.4 pt per acre.	Not for use on cowpea. Do not apply Quadris Opti more than twice before alternating to a fungicide not in group II. 14 days PHI.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
PEAS (CONT.)		
Asian soybean rust	Headline at 6 to 9 fl oz per acre mixed with an adjuvant and a fungicide from a group other than group II.	Pea and cowpea do not appear to be very susceptible to Asian soybean rust. 21 days PHI.
Fusarium wilt	Plant resistant varieties. Crop rotation for several years.	Rotate with nonhost crops.
Virus diseases	Use virus-free seed. Control aphids effectively.	Several viruses that infect peas are spread by aphids.
PEPPER		
Anthracnose	Use pathogen-free seed/disease-free transplants.	
	Amistar at 2 to 5 oz per acre or Quadris at 6.0 to 15.5 oz per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. 0 days PHI.
	Cabrio at 8.0 to 12 oz per acre.	Do not make more than 2 applications before alternating to a fungicide with a different mode of action. 0 days PHI.
	Maneb 75DF or Maneb 80WP at 1.5 to 3.0 lb per acre or Manex at 1.2 to 2.4 qt per acre.	7 days PHI.
	Tanos at 8.0 to 10.0 oz per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. 3 days PHI.
Bacterial spot	Use resistant varieties wherever possible.	Several races of pathogen exist.
	Use pathogen-free seed/disease-free transplants.	
	2-year crop rotation.	Avoid planting pepper or tomato.
	Avoid working in fields when plants are wet.	
	Copper products (e.g., Kocide, Champ, Caprofix) are labeled for greenhouse and field use. Combining a copper fungicide with Maneb will enhance effectiveness.	Follow label directions.
	Agri-mycin 17 at 200 ppm.	Begin application at the 2-leaf stage. Follow the label directions.
Blossom-end rot	Avoid moisture fluctuations. Avoid excessive nitrogen or potassium fertilization, rapid plant growth, and root pruning during cultivation. Maintain soil pH and calcium levels in desired range. Choose less susceptible varieties.	Blossom-end rot is caused by calcium deficiency in the fruit. Wide fluctuation in soil water levels can trigger the disorder.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
PEAS (CONT.)		
Phytophthora blight	Avoid waterlogged root zones.	Planting on raised beds will increase soil drainage.
	Several-year crop rotation.	Rotate to nonhost crops.
	Use resistant varieties.	Several resistant varieties are available.
	Ridomil Gold EC at 1 pt per acre at planting.	Will not be effective in poorly drained fields. 7 days PHI.
	Acrobat at 6.4 oz per acre or Forum at 6.0 fl oz per acre.	Do not make more than 2 applications before alternating to a fungicide with a different mode of action. 0 days PHI.
	Agri-Fos at 1.5 to 2.0 qt per acre or Phostrol at 1 to 2 qt per acre.	0 days PHI.
	Maneb at 1.5 to 3 lb per acre or Manex at 1.2 to 2.4 qt per acre.	7 days PHI.
	Tanos at 8 to 10 oz per acre.	Tank-mix with an appropriate contact fungicide with a different mode of action. 3 days PHI.
Powdery mildew	Amistar at 2 to 5 oz per acre or Quadris at 6.0 to 15.5 fl oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 0 days PHI.
	Cabrio at 8 to 16 oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 0 days PHI.
Root-rot nematode	Avoid fields with high populations of nematodes.	
	Methyl bromide or sodium methyl dithiocarbamate or Vydate L.	Methyl bromide and sodium methyl dithiocarbamate give best results when nematode populations are moderate to high. Vydate gives adequate control when nematode populations are low to moderate.
Virus diseases	Grow resistant varieties.	
	Plant disease-free transplants.	
	Eliminate broadleaf weeds within 150 feet of field before crops are established.	Aphids may spread viruses from weeds to pepper plants.
	Oil spray timed with aphid flight periods may prevent virus transmission by aphids.	
	Light-colored and reflective mulches may deter aphids from landing on plants and transmitting the virus.	

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
POTATO		
	Plant only certified seed tubers.	Seed-production fields should be inspected for viral, nematode, and fungal diseases.
	Good sanitation and seed-handling practices reduce losses.	
Seed-piece decay, tuberborne diseases	Plant whole tubers or cut-seed tubers that have been stored under conditions for rapid healing of cut surfaces.	
	Store seed tubers at 40°F during winter. In spring, warm seed to 65° to 70°F for 2 to 3 weeks before cutting.	
Early blight	Plant a cultivar with some resistance to early blight.	
	Avoid stressful conditions (e.g., drought, wetness, soil compaction) in early growth stages.	
	2- to 3-year crop rotation.	Do not rotate with tomato.
	Amistar at 2 to 5 oz per acre or Quadris at 6.2 to 12.4 fl oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 14 days PHI.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	7 days PHI.
	Endura at 2.5 to 4.5 oz per acre.	Do not make more than 2 applications before alternating to a fungicide with a different mode of action. 30 days PHI.
	Gavel at 1.5 to 2 lb per acre.	3 days PHI.
	Gem at 2.9 to 3.8 fl oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 7 days PHI.
	Headline at 6 to 9 oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 3 days PHI.
	Mancozeb (e.g., Dithane, Manzate, Penncozeb) at various rates.	14 days PHI.
	Maneb or Manex at 0.8 to 1.6 qt per acre for liquid formulations or 1.5 to 2.0 lb per acre for dry formulations.	14 days PHI.
	Quadris Opti at 1.6 pt per acre.	Do not make more than 1 application before alternating to a fungicide not in group II. 14 days PHI.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
POTATO (CONT.)		
Early blight (cont.)	Reason at 5.5 to 8.2 oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 14 days PHI.
	Rovral at 11 to 21 oz per acre for dry formulations and 1 to 2 pt per acre for liquid formulations.	Follow label directions. 14 days PHI.
	Scala at 7 oz per acre.	Tank-mix with another effective early-blight fungicide. 7 days PHI.
	Super Tin 80WP at 6 to 8 oz per acre.	7 days PHI.
	Tanos at 6 oz per acre.	Follow label directions. 14 days PHI.
Fusarium dry rot	Mertect at 0.42 oz per 2,000 lb of tuber. Treat tubers before going into storage.	Apply uniformly as a fine mist. Avoid bruising at harvest. Cure wounds at 60°F before storing at 40°F. Provide adequate ventilation.
Late blight	Destroy all potato cull piles.	
	Acrobat at 4 to 6.4 oz per acre or Forum at 6.0 fl oz per acre.	4 days PHI.
	Amistar at 4.0 oz per acre or Quadris at 12.0 fl oz per acre.	See remarks on early blight. 14 days PHI.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	7 days PHI.
	Curzate at 3.2 oz per acre.	Use only in combination with a labeled contact fungicide. 14 days PHI.
	Gavel at 1.2 to 2.0 lb per acre.	14 days PHI.
	Gem at 3.8 oz per acre.	See remarks on early blight. 7 days PHI.
	Headline at 6.0 to 12.0 oz per acre.	See remarks on early blight. 3 days PHI.
	Mancozeb (e.g., Dithane, Manzate, Penncozeb) at various rates.	14 days PHI.
	Maneb or Manex at 0.8 to 1.6 qt per acre for liquid formulations or 1.5 to 2.0 lb per acre for dry formulations.	14 days PHI.
	Quadris Opti at 1.6 pt per acre.	See remarks on early blight. 14 days PHI.
	Ranman at 1.4 to 2.75 fl oz per acre.	7 days PHI.
	Reason at 5.5 to 8.2 oz per acre.	See remarks on early blight. 14 days PHI.
	Ridomil Gold Bravo at 2.5 lb per acre or Ridomil Gold MZ at 2.5 lb per acre.	Do not apply more than once before alternating to a fungicide with adifferent mode of action. 14 days PHI.
	Super Tin 80WP at 2.5 to 3.75 oz per acre.	7 days PHI.
	Tanos at 6 to 8 oz per acre.	Follow the label directions. 14 days PHI.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
POTATO (CONT.)		
Rhizoctonia canker	Avoid heavily infested fields. Plant uncontaminated seed tubers.	
Scab	Plant resistant varieties. 3- to 4-year crop rotation.	Do not apply manure or other organic matter immediately before planting. Avoid excessive liming. Maintain acidic soil pH.
Verticillium wilt	2-year or longer crop rotation.	Rotate with small grains. Control weeds.
Root-knot and lesion nematodes	Methyl bromide, sodium methyl dithiocarbamate, or Vydate L.	Avoid fields with high populations of root-knot or lesion nematodes. Methyl bromide and sodium methyl dithiocarbamate give best results when nematode populations are moderate to high. Vydate gives adequate control when nematode populations are low to moderate.
Virus diseases	Plant only certified seed tubers. Control aphids and leafhoppers with insecticides.	Practice clean cultivation. Rouge first infected plants.
RHUBARB		
Ascochyta leaf spot	Fertilize in the fall for growth in the spring.	Remove older, yellow leaves or leaves with lesions in the fall.
Crown rot	Use disease-free plants.	Plant in well-drained soil.
SPINACH		
Damping-off	Ridomil Gold EC at 1 to 2 pt per acre.	Apply preplant to the soil surface and incorporate to a depth of 2 inches. 21 days PHI.
Downy mildew and white rust	Actigard at ¾ oz per acre. Aliette at 3 to 5 lb per acre (alone) or 2 to 3 lb per acre tank-mixed with another fungicide. Agri-Fos at 2 qt per acre or Phos-trol at 2.5 to 5.0 pt per acre. Amistar at 2 to 5 oz per acre for white rust and 4 to 15 oz per acre for downy mildew. Quadris at 6.0 to 15.5 fl oz per acre for white rust and 12.3 to 15.4 fl oz for downy mildew. Copper sulfate at various rates. Ridomil Gold EC or Ridomil Gold Copper.	7 days PHI. 3 days PH. 0 days PHI. Follow label directions. 0 days PHI. Follow label directions. Follow label directions. 21 days PHI.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
SWEET CORN		
Seed rot, seedling blight	Plant seed treated with captan, Dynasty, Protégé, or thiram. Plant in warm, well-drained soil.	Follow label directions.
Anthracnose	Amistar at 3 to 5 oz per acre or Quadris at 9 to 15.5 fl oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 7 days PHI.
Helminthosporium leaf blights	Plant resistant varieties.	
	Amistar at 3 to 5 oz per acre or Quadris at 9.0 to 15.5 fl oz per acre.	Do not make more than 1 application before alternating to a fungicide with a different mode of action. 7 days PHI.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	Do not apply to sweet corn that is to be processed. Follow label directions. 14 days PHI.
	Mancozeb (e.g., Dithane, Manzate, Penncozeb) or maneb (Maneb, Manex) at various rates.	Follow label directions. 7 days PHI.
	Quilt at 7 to 14 fl oz per acre.	Alternate application with a fungicide other than Tilt and fungicides in group II. 14 days PHI.
	Tilt or Propimax at 2 to 4 fl oz per acre.	14 days PHI.
Rust	Plant rust-resistant hybrids.	Be aware of the new races of the pathogen.
	Amistar at 2 to 3 oz per acre or Quadris at 6 to 9 fl oz per acre.	See remarks on Helminthosporium leaf blight. 7-day intervals.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	See remarks on Helminthosporium leaf blight. 14 days PHI.
	Mancozeb (e.g., Dithane, Manzate, Penncozeb) or maneb (e.g., Maneb, Manex) at various rates.	Follow label directions. 7 days PHI.
	Quilt at 10.5 to 14 fl oz per acre.	See remarks on Helminthosporium leaf blight. 7 days PHI.
	Tilt or Propimax EC at 4 fl oz per acre.	14 days PHI.
Smut	Plant less susceptible hybrids. Avoid mechanical damage to corn plants.	Avoid plant stresses that enhance smut infection.
Stewart's wilt	Plant wilt-resistant hybrids. Treat the seed with an effective insecticide to control flea beetles.	Insecticide treatments are more likely to be necessary in seasons following a mild winter.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
SWEET CORN (CONT.)		
Virus diseases (maize dwarf mosaic, chlorotic dwarf, wheat-streak mosaic)	Plant resistant or tolerant varieties. Control Johnsongrass and volunteer wheat.	
SWEET POTATO		
Black rot, root rot, Fusarium wilt, scurf	Plant resistant varieties. Plant pathogen-free seed. 3- to 4-year crop rotation. Prevent bruising tubers and maintain proper storage temperatures. Dip roots or sprouts in Mertect at 8 fl oz per 7.5 gal. water.	Dip in Mertect solution for 2 minutes and plant immediately.
Storage rot	Fumigate storage boxes.	Cure and store only healthy, blemish-free tubers.
TOMATO (FIELD)		
Seed decay and damping-off	Plant pathogen-free seed. Treat seeds in hot water or acidified hot water and then treat with captan or thiram.	Hot-water or acidified hot-water treatment must be carried out carefully because seed germination could be affected.
Anthracnose	3- to 4-year crop rotation. Amistar at 1.6 to 2.0 oz per acre or Quadris at 5.0 to 6.2 fl oz per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. 0 days PHI.
	Cabrio at 8.0 to 12.0 fl oz per acre.	Do not apply more than twice before alternating to a fungicide with a different mode of action. 0 days PHI.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	0 days PHI.
	Flint at 3 to 4 oz per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. 3 days PHI.
	Mancozeb (e.g., Dithane, Mancozeb, Penncozeb) or maneb (e.g., Maneb, Manex) at various rates.	5 days PHI.
	Quadris Opti at 1.6 pt per acre.	Do not apply Quadris Opti 21 days after transplanting or 35 days after seeding. Do not apply more than once before alternating to a fungicide with a different mode of action. 0 days PHI.
	Tanos at 8 oz per acre.	Tanos should be mixed with a contact fungicide with a different mode of action and should be alternated with a fungicide with a different mode of action. 3 days PHI.
	Ziram at 3 to 4 lb per acre.	Not for cherry tomatoes. 7 days PHI.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
TOMATO (FIELD) (CONT.)		
Bacterial canker	3-year or longer crop rotation.	Rotate to crops other than tomato, potato, pepper, or eggplant.
	Sanitize machinery and plant production materials (flats, greenhouse benches, and stakes) with bleach or other appropriate solution.	
	Plant pathogen-free seed / disease-free transplants.	
	Seed treatment with acidified hot water.	Follow the protocol carefully.
	Tanos at 8 oz per acre.	See remarks on anthracnose. 3 days PHI.
Bacterial spot, bacterial spec	Plant pathogen-free seed / disease-free transplants.	
	2- to 3-year crop rotation.	
	Agri-mycin at 200 ppm.	Begin applications at the 2-leaf stage on a 4- to 5-day schedule until transplants are in the fields.
	Copper compounds (e.g., Champ, Kocide, Cuprofix) at label rates.	Greenhouse rates are different from field rates. Follow label directions.
	Actigard at 0.33 to 0.75 oz per acre.	Up to 6 weekly applications. Follow label directions. 14 days PHI.
	Tanos at 8 oz per acre.	See remarks on anthracnose. 3 days PHI.
Blossom-end rot	Plant tomato varieties less prone to blossom-end rot.	This is a disorder related to calcium deficiency. Blossom-end rot is promoted by variance in available water and excessive vine growth rate. Maintain an even irrigation schedule.
Buckeye rot	3-year crop rotation.	
	Avoid low areas of the field.	Plastic mulch may reduce splash infection.
	Amistar at 1.6 to 2.0 oz per acre or Quadris at 5.0 to 6.2 fl oz per acre.	See remarks under anthracnose. 0 days PHI.
	Gavel at 1.5 to 2.0 lb per acre.	Follow label directions. 5 days PHI.
	Quadris Opti at 1.6 pt per acre.	See remarks on anthracnose. 0 days PHI.
	Ridomil Gold EC at 1 pt per acre.	Follow label directions. 28 days PHI.
	Tanos at 8 oz per acre.	See remarks on anthracnose. 3 days PHI.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
TOMATO (FIELD) (CONT.)		
Early blight, Septoria leaf blight	Plant resistant varieties.	Use wilt-resistant varieties.
	3- to 4-year crop rotation.	
	Amistar at 1.5 to 2.0 oz per acre or Quadris at 5.0 to 6.2 fl oz per acre.	See remarks on anthracnose. 0 days PHI.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	0 days PHI.
	Endura at 2.5 to 3.5 oz per acre.	Early blight only. Do not make more than 2 sequential applications before alternating to a fungicide with a different mode of action. 0 days PHI.
	Flint at 2 to 3 oz per acre for early blight and 3 to 4 oz per acre for Septoria leaf blight.	Follow label directions. 3 days PHI.
	Gavel at 1.5 to 2.0 lb per acre.	Follow label directions. 5 days PHI.
	Mancozeb (e.g., Dithane, Manzate, Penncozeb) at various rates.	5 days PHI.
	Quadris Opti at 1.6 pt per acre.	See remarks on anthracnose. 0 days PHI.
	Reason at 5.5 to 8.2 fl oz per acre.	Septoria suppression only. Do not make more than 1 application before alternating to a fungicide with a different mode of action. 14 days PHI.
	Scala at 7.0 fl oz per acre.	Early blight only. Scala may be used in greenhouses. Use only in tank mixture. Follow label directions. 1 day PHI.
	Tanos at 6 to 8 oz per acre.	See remarks on anthracnose. 3 days PHI.
	Ziram at 3 to 4 lb per acre.	Not for cherry tomatoes. 7 days PHI.
Botrytis gray mold		
	Keep greenhouse temperature 70°F or higher and keep relative humidity below 90%.	Use ventilation or forced air.
	Lime soil and keep fertility level up.	Calcium to phosphorus ratio of 2 or higher in leaf petiol tissues aids in control.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	Field use only. Follow label directions. 0 days PHI.
	Copper compounds at various rates.	Copper used for control of bacterial diseases will reduce gray mold severity.
	Endura at 9.0 to 10.5 oz per acre.	See remarks on early blight. 0 days PHI.
	Scala at 7 fl oz per acre.	See remarks on early blight. 1 day PHI.
Late blight		
	Acrobat at 6.4 oz per acre or Forum at 6.0 fl oz per acre.	Follow label directions. 4 days PHI.
	Agri-Fos at 1.5 to 2.0 qt per acre.	0 days PHI.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
TOMATO (FIELD) (CONT.)		
Late blight (cont.)	Amistar at 2.0 oz per acre or Quadris at 6.0 fl oz per acre.	See remarks on anthracnose. 0 days PHI.
	Cabrio at 8 to 16 oz per acre.	See remarks on anthracnose. 0 days PHI.
	Chlorothalonil (e.g., Bravo, Echo, Equus) at various rates.	0 days PHI.
	Curzate at 3.2 to 5.0 oz per acre.	Tank-mix with a contact fungicide. 3 days PHI.
	Flint at 4 oz per acre.	Follow label directions. 3 days PHI.
	Gavel at 1.5 to 2.0 lb per acre.	Follow label directions. 5 days PHI.
	Mancozeb (e.g., Dithane, Manzate, Penncozeb) at various rates.	Follow label directions. 5 days PHI.
	Previcur Flex at 0.7 to 1.5 pt per acre.	Tank-mix with a protectant fungicide. 5 days PHI.
	ProPhyt at 4 pt per acre.	0 days PHI.
	Quadris Opti at 1.6 pt per acre.	See remarks on anthracnose. 0 days PHI.
	Ranman at 2.1 to 2.75 fl oz per acre.	0 days PHI.
	Reason at 5.5 to 8.2 fl oz per acre.	Do not apply more than once before alternating to a fungicide with a different mode of action. 14 days PHI.
	Ridomil: Several formulations are labeled for late blight control.	PHI varies by formulation. Follow label directions.
Powdery mildew	Amistar at 1.6 to 2.0 oz per acre or Quadris at 5.0 to 6.2 fl oz per acre.	See remarks on anthracnose. 0 days PHI.
	Nova at 2.5 to 4.0 oz per acre.	0 days PHI.
	Quadris Opti at 1.6 pt per acre.	See remarks on anthracnose. 0 days PHI.
Sclerotinia stem rot	Use disease-free transplants.	Avoid fields with a history of stem blight.
Phythophthora blight	Avoid fields with a history of the disease.	The pathogen overwinters as thick-walled oospores in the soil. The spores survive several years.
	Avoid poorly drained fields.	
	Avoid close proximity to pepper or cucurbit fields that sustained Phytophthora blight in the past.	
	Ridomil Gold EC at 4 pt per acre may reduce disease incidence.	Applied to soil at planting.
	Ridomil Gold Bravo may be effective as foliar application.	Follow label directions.
	Application of Chlorothalonil or mancozeb may offer some control of the disease.	Follow label directions.

Table 3. Recommendations on management for diseases of commercial vegetable crops for 2008 (cont.)

Vegetable and disease	Treatment	Remarks
TOMATO (FIELD) (CONT.)		
Root-knot nematode	Plant root-knot-resistant varieties wherever available.	
	Avoid fields with high populations of root-knot nematodes.	Sample fields prior to planting tomatoes.
	Methyl bromide or sodium methyl dithiocarbamate or Vydate L.	Methyl bromide or sodium methyl dithiocarbamate gives best results when nematode populations are moderate to high. Vydate gives adequate control when nematode populations are low to moderate.

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Brush Control in Illinois

Brush control is used to improve and maintain pastures, recreational areas, fencerows, drainage-ditch banks, rights-of-way, and other noncrop areas. Table 1 lists the common and scientific names of the brush species referred to in this chapter. Brush can be controlled by mechanical or chemical methods (herbicides) or by a combination of mechanical removal of the plant and herbicides either to control the plant or to minimize resprouting.

Mechanical Control

Mechanical brush control is time-consuming and costly, but it may be necessary in areas where herbicide use is undesirable. Brush can be controlled by cutting, girdling, or grubbing. *Cutting brush* at ground level can be successful if sprouts are controlled by multiple cuttings or by the use of herbicides. Brush should be cut when food reserves in the roots are lowest (in the spring after full leaf) to minimize production of new sprouts. Any sprouts that develop should be removed until new sprouts no longer develop.

Girdling requires cutting a ring of bark and sapwood (the cambium layer) completely around the trunk of a woody plant to inhibit water and nutrient flow between roots and shoots. This practice is most effective in the summer months during sap flow. Girdling is practical only for scattered stands of large trees, as it is labor intensive.

Grubbing is the uprooting of plants by pulling or digging. Grubbing is difficult, time-consuming, and costly; but it can be effective if an adequate amount of the root system is removed. Bulldozers are often used to remove brush or trees and are most effective when fitted with special attachments for cutting off the tree below the groundline to lift out the tree and most of the larger roots.

Chemical Control

Chemical brush control with herbicides is generally less time-consuming and labor intensive than mechanical control. However, chemical control does not remove the dead plants; and foliar "brownout," or dead leaves, may be considered unsightly or offensive in areas of high visibility. An effective chemical brush-control program should be carefully planned and applied to minimize potential environmental and financial risk.

Brush herbicides are registered (labeled) only for certain areas and methods of application. Table 2 lists common brush herbicides and indicates the areas for which they are labeled, the appropriate application methods, and the general types of brush they control. Herbicides applied in pastures or where livestock graze must have grazing and harvest clearances. Some herbicides cannot be applied to aquatic areas, drainage ditches, or areas where they could run off or leach into aquatic areas. Information in this chapter has been taken from herbicide labels, so consult current labels because the information changes over time. Be sure to note and closely follow label restrictions and recommendations, and make applications carefully. Herbicides and their rates for use in brush control are listed in Table 3.

Methods of Application

Brush herbicides may be applied to the leaves (foliar treatment), onto or into the stem or trunk (basal-bark

The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.

Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.

or cut-surface treatment), or to the soil (Table 2). The best choice depends on many factors, including the herbicide, the site, the season of the year, and the environment. Tables 4 to 7 describe the susceptibility of common brush species to various herbicides applied by foliar, basal-bark, cut-surface, cut-stubble, or soil application. Much of this information was taken from *Response of Selected Woody Plants in the United States to Herbicides* (Agriculture Handbook no. 493, USDA), but it has been modified to match new label and manufacturer information.

Foliar treatments are most effective when sprays are applied just after full-leaf expansion, during late spring or early summer; adequate foliar coverage is essential. Foliar herbicide effectiveness is often improved by adding spray adjuvants such as oils (see labels for information). Effectiveness is often reduced if rainfall occurs too soon after application. Adverse temperature and moisture stress also affect foliar penetration and translocation of the herbicide. Foliar applications may be made as low- or high-volume sprays, depending on the equipment, the need for spray coverage, the size of the area, and the sensitivity of the surrounding area to drift. Applications may be broadcast or made as directed sprays with spray guns. Foliar treatments should usually be limited to shrubs or small trees because the drift potential is greater with tall trees.

Drift potential changes with the weather, the choice of herbicide, the herbicide formulation, and the spray equipment. Do not spray when the wind velocity is greater than 5 to 10 miles per hour or when the wind is blowing toward sensitive desirable plants or critical areas. Do not apply low-volume sprays (smaller droplets) during periods of high temperature or low humidity. Low-pressure sprayers have less drift potential than high-pressure sprayers. Specialized nozzles or spray thickeners (drift-reduction agents) may be used to reduce small-droplet formation and spray drift. Certain herbicide formulations volatilize and should not be used when minimizing drift is crucial. Some herbicide labels list sensitive species and critical areas that must be protected from drift or direct application. *Read and follow label precautions about spray or vapor drift to susceptible plants or sensitive areas.*

Basal-bark treatments are more labor intensive than foliar treatments, but they are useful as a technique for selectively removing undesirable species from stands of desirable trees. These treatments are used to control brush with trunks or stems less than 5 inches in diameter. Basal-bark treatments may be made throughout the year except when the bark is very wet or covered with ice or when the depth of snow prevents application. However, dormant-season application may be desirable to reduce drift complaints and concerns about foliar brownout.

Oil-soluble, usually ester, formulations of herbicides are applied in diesel oil or kerosene to penetrate the bark. Penetrating oils with less offensive odors are available, but they are more expensive. Standard basal-bark treatments are applied around the lower 12 to 15 inches of the stem, including the root collar and exposed roots. Conventional basal-bark technique uses 1 to 3 percent herbicide in oil, while the low-volume basal-bark technique uses 20 to 30 percent herbicide in oil. Smaller bands (broad band or thin line) using a higher concentration of herbicide in oil can be effective on many species. Follow instructions on the herbicide label.

Cut-surface treatments are used to control trees having thick bark or trunks greater than 5 inches in diameter. Application may be made anytime except during heavy sap flow in the spring. Dormant-season application minimizes the potential for drift and foliar brownout complaints. The herbicide is applied into frills or notches cut around the trunk, going through the bark to penetrate at least ½ inch into the sapwood. Treat cuts within 2 to 3 hours of cutting. Special equipment often is used to cut and inject the herbicide into the tree in one operation, reducing labor cost and drudgery. You can minimize sprouting from freshly cut stumps by treating the area next to the bark (cambium) and drenching the root collar (soil at ground level) soon after cutting.

Cut-stubble treatments combine cut-surface and soil treatment. Herbicide is broadcast in a water carrier to cut stems and exposed ground soon after a mowing operation. Applications may be made anytime during the year except when the ground is frozen or completely saturated with water. Apply carefully to minimize drift or runoff to off-target species or sensitive areas.

Soil treatments, sometimes called basal-soil, are applied within the dripline of the target species so the herbicide can move by rainfall into the root zone. Soil treatments are applied as sprays, granules, or pellets. Because the soil-treatment herbicides are quite persistent and mobile in water, do not use them where they can run off toward or leach into surface- or underground water sources. Do not apply them to frozen ground or land sloping toward nontarget species where lateral movement will be a problem. The killing of nontarget species has been one of the major problems with soil treatments.

Brush Herbicides

Some brush herbicides are selective, leaving grasses unharmed while controlling brush and broadleaf

weeds. These herbicides can injure desirable broadleaf plants if they are allowed to drift, run off, or leach out of the treatment area. Nonselective herbicides are potentially hazardous to desirable plants, but they may be used as spot treatments to control brush if applied carefully. If possible, dedicate application equipment to a single use or be sure to clean the equipment thoroughly. Most labels have recommendations for type of application equipment and equipment cleaning. Brush herbicides may be growth-hormone regulators, foliar phosphono herbicides, ALS amino acid–synthesis inhibitors, or photosynthetic inhibitors. Each type has specific advantages and disadvantages.

Growth-hormone regulator herbicides are absorbed by foliage and plant roots and translocated to growing areas (meristems). These herbicides include 2,4-D, dichlorprop, dicamba, picloram, and triclopyr, plus many mixtures. Prevent drift or runoff into sensitive areas because minute amounts may injure highly sensitive species. Ester formulations are more subject to vapor drift than are amine formulations although dicamba amine can hydrolyze and then volatilize. Vapors can move far from the site of application. Do not apply any of these herbicides when the temperature is expected to exceed 85°F within several days. Ester formulations may be applied in oil carriers for basal-bark treatments, while amine formulations are preferable for injection and cut-surface treatments.

Foliar treatments are often more subject to drift than are other methods of application. Symptoms of injury from growth-hormone herbicides are usually foliar deformities (strapping or cupping) and stem or petiole twisting (epinasty). These herbicides have foliar and soil activity, so do not treat areas where the herbicide may leach or run off and contact the roots of desirable species. Closely follow all restrictions on the labels.

2,4-D, dichlorprop, and **dicamba**, as well as their mixtures, are registered for brush control on drainage-ditch banks, rights-of-way, and noncrop areas. Dicamba and 2,4-D also are registered for brush control in pastures, but follow label restrictions on grazing. 2,4-D is sold under many trade names as esters, amines, or salts.

DPD Ester Brush Killer is a dichlorprop ester plus 2,4-D ester formulation, while **Brushmaster** is a mix of 2,4-D ester, dichlorprop ester, and dicamba amine. **Banvel, Clarity, Sterling,** or **Vanquish** (dicamba) and **Weedmaster** or **Brash** (dicamba + 2,4-D) may be used for brush control in noncropland or pasture. Clarity and Vanquish are the diglycoylamine formulations of dicamba, with fewer volatility problems than Banvel, which is a dimethylamine.

Tordon K (picloram) and **Tordon 101 Mixture, Grazon P + D,** or **Pathway** (picloram + 2,4-D) contain the amine formulation of picloram. Tordon K and Tordon 101 Mixture are restricted use pesticides (RUPs). Pathway, however, is a ready-to-use (RTU), general use herbicide for cut-surface or injection application only.

Garlon 3A (triclopyr amine); **Garlon 4, Pathfinder II,** or **Remedy** (all esters); and **Crossbow** (triclopyr ester + 2,4-D ester) all contain triclopyr, which is much less persistent than picloram. All can be used for noncropland brush control. Pathfinder II is an RTU formulation for basal-bark or cut-stump treatment. Crossbow may also be used in grass pastures as a foliar treatment. Check the label for grazing and haying restrictions.

Foliar phosphono herbicides such as fosamine and glyphosate are applied to the foliage because they have little soil activity. **Krenite S** (fosamine) may be used where foliar brownout is a problem because treated foliage does not immediately die. It goes through normal fall coloration and leaf drop; but, the next spring, susceptible plants fail to refoliate, and they die. Thorough spray coverage is required for complete control. A spray directed to only part of a susceptible species results in a trimming effect without killing the entire plant.

Glyphosate (many formulations) may be used for foliar treatments. There are many different glyphosate formulations; see labels for which ones are used for noncropland, forestry, utility rights-of-way, and general use (including cropland). Some trade names for these products are Roundup Pro, Accord, Glyfos, Touchdown, Credit, and Roundup Weathermax. The glyphosate formulation used for aquatic applications is Rodeo. Glyphosate is nonselective, so it should be applied as a spot treatment for brush where loss of ground cover is detrimental. Some formulations can be used for spot treatment of brush in pastures, but check the product label for grazing restrictions.

ALS amino acid–synthesis inhibitors for brush control are imazapyr and metsulfuron. They control both herbaceous and woody broadleaf plants and may suppress or kill some grass species, so read labels carefully before applying near desirable species or sensitive areas. Plants absorb imazapyr and metsulfuron through both foliage and roots and translocate them to growing (meristematic) areas. Growth inhibition of susceptible species occurs rapidly, but typical symptoms of action may not be visible for some time after application. Ultimate effects on brush species may not occur until the season after treatment.

Arsenal, Chopper, and **Stalker** contain imazapyr. Arsenal is for general noncropland use, Arsenal AC for forestry use. Chopper and Stalker are registered for noncropland basal-bark and cut-surface brush treatments. Imazapyr controls a broad spectrum of woody and herbaceous (broadleaf and grass) species. Arsenal may be applied pre- or postemergence; but to control perennials, including brush species, postemergence is the method of choice.

Metsulfuron is sold as **Escort** for industrial use and as **Ally** and **Cimarron** for pasture use. Apply as a foliar treatment for control of selected brush species (Table 2). For greatest effectiveness, complete spray coverage of foliage and stems is necessary.

Photosynthetic inhibitor (PSI) herbicides used for soil-applied brush control include bromacil, hexazinone, and tebuthiuron. Because these herbicides translocate only in the xylem, they are generally soil applied for brush control; but, when applied to foliage, they provide contact-type activity, especially when a surfactant is added. Injury symptoms on brush are generally slow to appear from soil application because the herbicides require rainfall to infiltrate the soil and to be taken up by the roots. These herbicides are nonselective, so avoid application to the foliage or near the root zone of desirable plant species. Spot treatment is necessary where bare ground is undesirable.

Hyvar X (bromacil) may be soil applied for brush control. Hyvar X-L, a liquid formulation, may be soil applied undiluted with a special handheld applicator that delivers a predetermined volume when triggered. Hyvar X-L also is registered for soil-applied spot treatment of brush on ditch banks.

Velpar (hexazinone) is available as Velpar L or Velpar DF for spray application to soil in industrial or forestry areas. Velpar is registered for use in alfalfa. Thus, treated areas may be grazed or cut for hay when label restrictions are followed.

Spike (tebuthiuron) is available as Spike 80DF for spray application or Spike 20P for direct soil application of pellets. Spike 20P may be used for spot treatment of brush in pastures, but observe grazing and haying restrictions on the label.

Do not apply PSI herbicides to brush standing in water or spray toward water. Do not apply these herbicides to frozen soil or to areas sloping toward water or desirable species because these herbicides are quite mobile and persistent.

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Table 1. Common and scientific names of brush species

Common names	Scientific names
Ash, white	*Fraxinus americana*
Birch	*Betula* spp.
Box elder	*Acer negundo*
Brambles (blackberry, etc.)	*Rubus* spp.
Cedar, eastern red	*Juniperus virginiana*
Cherry, black and choke	*Prunus serotina, P. virginiana*
Cottonwood	*Populus deltoides*
Crabapple	*Malus* spp.
Elderberry	*Sambucus canadensis*
Elm	*Ulmus* spp.
Grapes, wild	*Vitis* spp.
Greenbriar	*Smilax* spp.
Hackberry	*Celtis* spp.
Hawthorn	*Crataegus* spp.
Honeylocust	*Gleditsia triacanthos*
Honeysuckle	*Lonicera* spp.
Locust, black	*Robinia pseudoacacia*
Maple, red	*Acer rubrum*
Maple, silver or sugar	*A. saccharinum, A. saccarum*
Mulberry, red and white	*Morus rubra, M. alba*
Oak	*Quercus* spp.
Olive, Russian	*Elaeagnus augustifolia*
Osage orange (hedge)	*Maclura pomifera*
Persimmon, common	*Diospyros virginiana*
Plum, wild	*Prunus* spp.
Poison ivy, poison sumac	*Toxicodendron radicanus, T. vernix*
Rose, multiflora	*Rosa multiflora*
Sassafras	*Sassafras albidum*
Sumac	*Rhus* spp.
Tree-of-heaven	*Ailanthus altissima*
Trumpetcreeper	*Campsis radicans*
Virginia creeper	*Parthenocissus quinquefolia*
Willow	*Salix* spp.

Table 2. Label clearances for common brush herbicides

	Area or site							Application method					Type of brush	
Brush herbicide	CRP areas	Pasture	Fencerows	Forest	Ditch bank	Rights-of-way	Noncrop	Foliar-stem spray	Cut-surface or injection	Conventional basal[a]	Low-volume basal[a]	Soil	Deciduous	Coniferous
2,4-D amine, ester	x	x	x	x	x	x	x	x	x	x[a]	x[a]	—	x	—
DPD Brush Killer	—	—	x	x	x	x	x	x	x	x	x	—	x	x
SuperBrush Killer or Brushmaster	—	—	x	—	x	x	x	x	x	x	—	—	x	x
Brash/Weedmaster	x	x	x	—	x	x	x	x	x	—	—	—	x	x
Dicamba (many)[b]	x	x	x	—	x	x	x	x	x	x[c]	—	—	x	—
Tordon K	—	—	—	x	—	x	x	x	—	—	—	x	x	x
Pathway (RTU)	—	—	x	x	—	x	x	—	x	—	—	—	x	x
Tordon 101 Mixture	—	—	—	x	—	x	x	x	x	—	—	x	x	x
Grazon P + D	x	x	—	—	—	—	x	x	—	—	—	—	x	—
Garlon	x	—	x	x	x	x	x	x	x	x[a]	x[a]	—	x	x
Remedy	x	x	x	x	x	x	x	x	x	x[a]	x[a]	—	x	x
Crossbow	x	x	x	—	x	x	x	x	—	x	x	—	x	x
Pathfinder II (RTU)	—	—	—	x	x	x	x	—	—	—	x	—	x	x
Krenite S	—	—	—	—	x	x	x	x	—	—	—	—	x	x
Glyphosate[d]	x	x[e]	x	x	x	x	x	x	x	—	—	—	x	x
Ally XP, Cimarron	x	x	—	—	—	x	x	x	—	—	—	x	x	x
Arsenal	—	—	x	x[f]	x	x	x	x	x	—	—	—	x	—
Escort XP	x	—	x	x	—	x	x	x	—	—	—	x	x	x
Stalker/Chopper	x	—	x	x	x	x	x	—	x	x	x	—	x	—
Hyvar-X or X-L	—	—	—	—	—	x	x	—	—	—	—	x	x	x
Spike	x	x[g]	x	—	—	x	x	—	—	—	—	x	x	x
Velpar	—	—	—	x	—	x	x	x	—	—	—	x	x	—

x = labeled for use; — = not labeled for use.
[a]Oil-soluble ester forms only.
[b]There are many dicamba formulations.
[c]Not for pasture use.
[d]Many trade names (for example, Accord, Roundup Pro, Touchdown, etc.). Be sure to read and follow label directions.
[e]Spot treatment only (10% of each acre).
[f]Use AC formulation.
[g]Soil application only.

Table 3. Herbicides and rates for brush control

Trade name and form	Generic name and form	Rate for foliar spray, ground application[a]		Rate for basal-bark per 100 gal.[c]
		Per acre	Per 100 gal.[b]	
Arsenal 2S	imazapyr	2–3 qt	0.5–1 gal.	—[d]
Brushmaster	dichlorprop + 2,4-D (esters) + dicamba amine	1–2 gal.	1–2 gal.	4 gal.
Crossbow 3E	triclopyr + 2,4-D (esters)	1.5–4 gal.	1–1.5 gal.	1–4 gal.
Dicamba (many)	dicamba	1–2 qt	—[d]	—[d]
DPD Brush Killer	dichlorprop + 2,4-D (esters)	1–2 gal.	1–1.5 gal.	3–4 gal.
Escort 60DF	metsulfuron	⅓–1 oz	1–3 oz	—[d]
Garlon 3A	triclopyr, amine	2–3 gal.	0.5–1 gal.	—[d]
Garlon 4E/Remedy	triclopyr, ester	0.5–2 gal.	1–2 gal.	1–5 gal.
Glyphosate (many)[e]	glyphosate	4–8 pt	1–2.5 gal.	1–2 gal.
Grazon P + D	picloram + 2,4-D (amines)	3 qt–1 gal.	2 gal.	—[d]
Hyvar X 80WP	bromacil	7–15 lb	—[d]	—[d]
Hyvar X-L 2S	bromacil	2.5–6 gal.	—[d]	—[d]
Krenite S, UT	fosamine	1.5–6 gal.	1.5–3 gal.	—[d]
Pathfinder II	triclopyr ester	—[d]	—[d]	RTU[f]
Spike 20P	tebuthiuron	10–30 lb	—[d]	—[d]
Stalker 2S	imazapyr	—[d]	—[d]	0.75–1 gal.
Tordon K	picloram	1–2 qt	—[d]	—[d]
Tordon 101	picloram + 2,4-D (amines)	1–2 gal.	—[d]	—[d]
Velpar 2L	hexazinone	2–4 gal.	—[d]	—[d]
Velpar 75DF	hexazinone	5–10 lb	—[d]	—[d]
Weedmaster 3.87S	dicamba + 2,4-D (amines)	2.0 gal.	—[d]	—[d]
Weedone LV4	2,4-D ester	1–2 gal.	2 gal.	—[d]

[a]See label for aerial application.
[b]Foliar mix: herbicide + water (+ 1 gal. oil + emulsifier if label allows).
[c]Basal-bark spray mix: herbicide + fuel oil total.
[d]Not labeled for this purpose.
[e]Rates based on 3 lb a.e. per gallon formulations.
[f]RTU = Ready-to-use formulation; apply undiluted.

Table 4. Foliar herbicide treatment: Susceptibility of common brush species

	2,4-D	Arsenal	Brushmaster	Crossbow	dicamba[a]	DPD Brush Killer	Escort	Garlon / Remedy	glyphosate[b]	Hyvar	Krenite S	Tordon 101 / Grazon P + D	Weedmaster
Ash, white	P	G	F	F	F	P	G	F	F	F	F	P	P
Birch	F	P	G	F	G	F	P	F	F	F	G	F	F
Box elder	F	F	G	F	—	F	P	P	FG	G	FP	G	F
Brambles (blackberry, etc.)	P	P	F	G	F	F	G	G	F	F	FG	F	F
Cedar, eastern red	P	P	P	P	FP	P	F	P	P	F	P	F	P
Cherry, black and choke	FP	G	F	FG	G	F	G	FG	G	G	F	FG	G
Cottonwood, eastern	FG	G	G	FG	G	F	F	G	F	G	FG	G	G
Crabapple	F	—	G	FG	G	G	—	FG	G	—	—	G	G
Elderberry	FG	G	G	FG	G	F	P	G	G	G	FG	G	G
Elm, American and slippery	F	P	F	F	F	F	G	F	F	F	F	F	F
Grapes, wild	FG	G	FG	G	F	FG	F	G	G	—	G	FG	F
Greenbriar	P	G	F	P	FP	P	P	FP	P	P	P	FP	F
Hackberry	FP	P	F	G	F	F	P	G	F	F	FP	FG	F
Hawthorn	FP	G	F	F	FP	P	G	F	FG	F	F	FG	F
Honeylocust	P	G	F	FG	FP	F	P	FG	P	F	F	G	P
Honeysuckle	F	G	F	FP	F	G	F	FP	F	F	F	G	F
Locust, black	F	P	G	G	G	FG	F	G	F	P	G	F	G
Maple, red	P	G	P	F	FP	P	F	FG	F	F	F	F	P
Maple, silver or sugar	P	G	F	G	F	—	G	G	F	F	F	F	F
Mulberry, red or white	P	G	F	F	F	P	P	F	P	F	F	F	P
Oak	P	G	F	F	F	F	FG	FG	FG	F	G	P	F
Olive, Russian	F	G	—	F	F	—	P	FG	F	—	F	G	F
Osage orange (hedge)	P	P	P	F	FP	P	F	F	P	F	F	F	P
Persimmon, eastern	F	F	F	F	FG	P	P	F	F	P	F	FG	FP
Plum, wild	FG	G	FG	F	FG	F	P	FG	G	—	FG	G	F
Poison ivy	F	G	F	G	FG	F	P	G	F	F	P	F	F
Rose, multiflora	F	G	G	G	G	G	F	FG	G	F	F	G	G
Sassafras	F	G	F	F	F	F	P	F	F	F	F	G	F
Sumac	F	G	G	G	FG	G	P	G	F	F	G	FG	G
Tree-of-heaven	F	F	F	FG	P	F	P	G	F	F	FG	FG	P
Trumpetcreeper	P	FP	FP	P	FG	P	P	P	F	P	F	P	F
Virginia creeper	FG	G	G	F	FP	F	G	F	F	G	P	F	F
Willow	G	G	G	G	FG	G	G	FG	F	F	F	G	G

G = good; F = fair; P = poor; FG = fair to good; FP = fair to poor; — = no information available. Data are adapted from *Response of Selected Woody Plants in the United States to Herbicides*, Agriculture Handbook no. 493, U.S. Department of Agriculture, and from herbicide companies.

[a]There are many dicamba formulations.

[b]There are many glyphosate formulations.

Table 5. Conventional basal-bark herbicide treatment: Susceptibility of common brush species

	2,4-D ester	Brushmaster	dicamba[a]	Garlon 4/ Remedy	Stalker	Weedone CB
Ash, white	P	FG	FG	G	G	P
Birch	G	F	G	G	G	F
Box elder	G	G	G	P	G	G
Brambles (blackberry, etc.)	FG	G	G	G	F	F
Cedar, eastern red	P	F	FG	F	P	P
Cherry, black and choke	F	F	G	G	G	F
Cottonwood, eastern	G	G	G	G	G	F
Crabapple	FG	G	G	—	—	FG
Elderberry	FG	G	G	G	G	FG
Elm, American and slippery	FG	FG	G	F	FG	F
Grapes, wild	—	F	F	FG	G	F
Greenbriar	F	F	P	P	G	P
Hackberry	G	F	FG	G	P	G
Hawthorn	F	F	FP	F	—	F
Honeylocust	F	F	F	G	FG	FP
Honeysuckle	G	G	G	P	G	F
Locust, black	F	F	FG	FG	P	F
Maple, red	P	P	G	FG	G	P
Maple, silver or sugar	FP	F	G	G	G	FP
Mulberry, red or white	P	FP	F	F	G	P
Oak	P	G	G	G	G	FG
Olive, Russian	—	—	F	FG	G	—
Osage orange (hedge)	F	F	P	P	P	F
Persimmon, eastern	FP	F	G	F	G	P
Plum, wild	FG	FG	G	P	G	FG
Poison ivy	F	F	FG	P	G	F
Rose, multiflora	F	FG	F	F	G	F
Sassafras	FG	FP	FG	FG	G	F
Sumac	F	F	G	G	G	G
Tree-of-heaven	FP	F	F	G	FG	F
Trumpetcreeper	P	G	FG	P	G	P
Virginia creeper	P	G	—	P	G	P
Willow	G	G	—	FG	G	F

G = good; F = fair; P = poor; FG = fair to good; FP = fair to poor; — = no information available. Data are adapted from *Response of Selected Woody Plants in the United States to Herbicides*, Agriculture Handbook no. 493, U.S. Department of Agriculture, and from herbicide companies.

[a]There are many dicamba formulations.

Table 6. Injection, cut-surface, and cut-stubble herbicide treatment: Susceptibility of common brush species

	2,4-D amine	Arsenal / Stalker	Brushmaster	dicamba[a]	DPD Brush Killer	Garlon 3A	Pathway
Ash, white	P	G	FG	G	F	F	FG
Birch	F	G	FG	G	FG	F	FG
Box elder	F	G	F	—	F	G	G
Cedar, eastern red	P	P	F	FG	F	FP	F
Cherry, black and choke	G	G	FG	—	FG	FG	G
Cottonwood, eastern	G	G	G	—	F	G	G
Crabapple	—	—	G	—	—	G	G
Elderberry	F	G	G	—	F	FG	G
Elm, American and slippery	G	F	FG	—	F	F	F
Grapes, wild	FG	F	FP	—	P	FG	FG
Greenbriar	P	P	F	—	F	P	P
Hackberry	F	P	F	—	F	G	G
Hawthorn	F	F	F	—	F	F	F
Honeylocust	F	F	G	—	G	F	G
Honeysuckle	P	G	F	—	F	P	G
Locust, black	G	F	G	—	FG	G	G
Maple, red	P	G	F	F	F	G	F
Maple, silver or sugar	P	G	F	FG	F	G	G
Mulberry, red or white	F	G	F	—	F	F	F
Oak	P	G	G	P	G	G	F
Olive, Russian	—	G	—	F	—	G	G
Osage orange (hedge)	F	P	F	—	F	F	F
Persimmon, eastern	F	G	F	G	F	F	F
Plum, wild	F	G	F	—	F	FG	F
Poison ivy	F	G	FG	—	FG	G	F
Rose, multiflora	FP	G	G	—	G	F	F
Sassafras	G	G	F	—	F	F	F
Sumac	F	G	G	—	G	G	F
Tree-of-heaven	F	FG	F	—	F	G	G
Trumpetcreeper	F	G	F	—	—	P	P
Virginia creeper	P	G	F	—	—	F	F
Willow	G	G	F	—	FG	FG	G

G = good; F = fair; P = poor; FG = fair to good; FP = fair to poor; — = no information available. Data are adapted from *Response of Selected Woody Plants in the United States to Herbicides*, Agriculture Handbook no. 493, U.S. Department of Agriculture, and from herbicide companies.

[a]There are many dicamba formulations.

Table 7. Soil herbicide treatment: Susceptibility of common brush species

	Hyvar X-L	Spike 20P	Velpar
Ash, white	F	F	F
Birch	FG	FG	F
Box elder	G	G	FG
Brambles (blackberry, etc.)	F	F	F
Cedar, eastern red	F	FP	F
Cherry, black and choke	FG	FG	FG
Cottonwood, eastern	FG	G	G
Crabapple	F	—	F
Elderberry	G	G	G
Elm, American and slippery	F	FG	F
Grapes, wild	G	G	FG
Greenbriar	P	F	P
Hackberry	FG	G	G
Hawthorn	P	F	G
Honeylocust	F	FG	G
Honeysuckle	F	G	G
Locust, black	G	F	G
Maple, red	F	F	F
Maple, silver or sugar	F	FG	G
Mulberry, red or white	F	G	FG
Oak	F	G	FG
Olive, Russian	—	FG	FG
Osage orange (hedge)	F	P	FG
Persimmon, eastern	F	P	F
Plum, wild	G	G	FG
Poison ivy, poison sumac	G	FP	FG
Rose, multiflora	F	G	G
Sassafras	F	P	FP
Sumac	G	G	F
Tree-of-heaven	FG	G	F
Trumpetcreeper	P	F	P
Virginia creeper	P	FG	F
Willow	FG	F	FG

G = good; F = fair; P = poor; FG = fair to good; FP = fair to poor; — = no information available. Data are adapted from *Response of Selected Woody Plants in the United States to Herbicides*, Agriculture Handbook no. 493, U.S. Department of Agriculture, and from herbicide companies.

9

Weed Control for Noncrop Areas

Total vegetation management is the application of nonselective chemicals or nonselective rates of selective chemicals as a means of controlling all vegetation in noncrop areas such as parking lots, drive-in theater lots, driveways, and certain industrial sites.

Herbicides may be classified by their length of control. Those with little or no residual activity are the contact herbicides, such as paraquat, which control only the existing vegetation that the spray contacts.

Dicamba gives residual control for 4 months or less. Products that provide longer control include bromacil, diuron, tebuthiuron, sulfometuron, prometon, and picloram.

Total vegetation management is desirable along fences, beneath asphalt pavement, along railroads, and around buildings as a means of preventing the growth of weeds that are unsightly or weeds that present a fire hazard. As an alternative to chemical control in some noncrop areas, it may be preferable to establish desirable, competitive vegetation to discourage weed growth and to provide protective soil and wildlife cover. Herbicides with little or no residual activity may be used for temporary control until desirable vegetation is established.

Precautions and General Procedures

Several precautions must be observed when nonselective chemicals are used. Know what weeds are to be controlled, and select the correct chemical for those particular problems. Survey the area, noting any desirable vegetation in the immediate area or adjacent areas that could be affected by spray drift, chemical runoff, or herbicide leaching into the root zone.

Appropriate precautions should be taken to prevent damage to desirable plants. The risk of injury with certain materials may be too great to allow their use in some areas. Be certain that you are familiar with the product, and be aware of the risks before using any herbicide. Some treatments should be made only by professional applicators.

The type of vegetation to be controlled will affect your choice of a chemical. For example, perennial grasses can be controlled with glyphosate; woody perennials can be controlled with 2,4-D, fosamine, picloram, triclopyr, or mixtures of some of these products. Deep-rooted vines, such as bindweed, can be controlled with dicamba, picloram, triclopyr, or premixes of these herbicides.

Herbicides for Noncrop Areas

Herbicides for Long-Term (Soil-Residual) Control

Trees and woody ornamentals are sensitive to these herbicides. Lateral movement or direct application over the rooting zone of desirable woody species can lead to liability and/or litigation. Spray applications (Table 1) used on large areas often involve water-dispersible (DF, DG, or L) formulations that require thorough spray agitation. Granular (G) or pellet (P) formulations (Table 2) are convenient for spot or small-area applications.

The best time to apply nonselective, soil-residual herbicides is early in the spring before herbaceous weeds have emerged. If vegetation is dense, it may be necessary to cut or mow existing vegetation. For a later application, add a contact or translocated foliar herbicide, or mix the herbicide with diesel fuel to speed

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The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.

Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.

Table 1. Spray applications for long-term weed control

Herbicide	Formulations	Rate of formulation per acre		
		Annuals	Some perennials	"Hard to control" perennials
Arsenal	2AS	2 to 4 pt	1 to 6 pt	4 to 6 pt
Hyvar X	80WP	3 to 6 lb	7 to 15 lb	7 to 15 lb
Hyvar X-L	2L	0.75 to 3 gal.	3 to 6 gal.	3 to 6 gal.
Karmex, Direx	80DF	5 to 15 lb	5 to 15 lb	5 to 15 lb
Krovar	80DF	4 to 6 lb	7 to 18 lb	19 to 30 lb
Oust XP	75DG*	3 to 5 oz	6 to 8 oz	6 to 8 oz
Pramitol 25E	2S	4 to 6 gal.	7.5 to 10 gal.	10 gal.
Spike	80DF	5 to 7.5 lb	2.5 to 5 lb	3.75 to 7.5 lb
Velpar	75DF	2.5 to 6.5 lb	6 to 10.67 lb	—
Velpar L	2L	1 to 2.5 gal.	3 to 4 gal.	—

— = not labeled for this formulation.
*Note that the rate of this product is in ounces per acre.

Table 2. Application rates for selected granular herbicides

Herbicide	Lb per 1,000 sq ft
Pramitol 5PS	3.5 to 9.2
Spike 20P	0.23 to 0.7
Topsite 2.5G	5 to 7

topkill. Follow label recommendations. After existing vegetation is under control, the rate of a soil-applied herbicide may be reduced for maintenance applications. Adjust application rates according to the soil type, the plant species to be controlled, and desired length of control.

Imazapyr and sulfometuron are acetolactate-synthase (ALS) inhibitors, while bromacil, diuron, hexazinone, prometon, and tebuthiuron are photosynthetic inhibitors (PSI). *Certain biotypes of weed species such as kochia are resistant to PSI and ALS herbicides.*

Arsenal 2AS (imazapyr) may be foliar- or soil-applied. **Topsite 2.5G** (imazapyr + diuron) is a granular formulation. **Oust XP 75DG** (sulfometuron) is primarily soil-applied.

Hyvar X 80WP and **Hyvar X-L 2L** (bromacil) are for spray application. *Hyvar X-L is combustible.* Bromacil also is formulated as a 4 percent granule under many trade names. **Karmex 80DF** (diuron) and **Krovar 80DF** (1:1 bromacil + diuron) are soil-applied, while **Velpar 2L** or **75DF** (hexazinone) may be foliar- or soil-applied. Do not use Hyvar, Krovar, or Velpar around wells or if surface water is present. The Velpar label carries the signal word "Danger," requiring eye protection and rubber gloves for handling.

Pramitol 25E (prometon) may be foliar- or soil-applied, while **Pramitol 5PS** is formulated for soil application only. **Spike 80DF** or **20P** (tebuthiuron) is soil-applied for broadleaf weed and brush control. Spike 20P may be used for brush control in pastures.

Herbicides for Short-Term (Nonresidual) Control

Gramoxone Inteon[RUP] **2S** (paraquat) is a contact herbicide. Use a crop-oil concentrate or nonionic surfactant, and adjust water volume to provide maximum coverage of vegetation. **Finale** (glufosinate) is another contact herbicide that can be used in noncrop areas. Maximum spray coverage is imperative for adequate control. Because **glyphosate** formulations are translocated (systemic) herbicides, they control perennial weeds better than Gramoxone Inteon and Finale.

Herbicides for Broadleaf Weed and Brush Control

Plant-Growth Regulators (PGR)—Primarily Foliar

2,4-D is sold under many trade names as acid, amine, salt, or ester formulations. Amines are nonvolatile, while ester formulations are subject to volatile drift under high temperatures. Because 2,4-D formulations

vary in acid equivalent (a.e.) per gallon or pound, rates per acre vary with trade names and formulations. 2,4-D is often mixed with other active ingredients to broaden the spectrum and reduce the cost of control.

Banvel 4S, Clarity 4L, Sterling 4S, or **Vanquish 4S** (dicamba); **Distinct 70WG** (dicamba + diflufenzopyr); **Brash** or **Weedmaster** (1:3 dicamba + 2,4-D); **Garlon 4E, Garlon 3A,** or **Remedy** (triclopyr); and **Crossbow** (2:1 triclopyr + 2,4-D) are used in noncrop land. Banvel, Clarity, Brash, Crossbow, Sterling, and Weedmaster also may be used in pastures.

Tordon K[RUP] 2S (picloram) and **Tordon 101 Mixture[RUP]** (picloram + 2,4-D) are formulated as amines for foliar application. **Pathway** (picloram + 2,4-D) is for cut-surface applications for brush control in noncrop land. *Do not use picloram in pastures in Illinois.*

DPD Ester Brush Killer (1:1 diclorprop + 2,4-D) or **Brushmaster 2E** (diclorprop + 2,4-D + dicamba) is for use in noncrop land. *Diclorprop is not registered for use in pastures.* **Stinger** or **Transline** (clopyralid) is used primarily for Canada thistle control.

Other Modes of Action

Arsenal 2AS (imazapyr) is used for foliar or soil application, while **Stalker 2S** (imazapyr) is for basal-bark or cut-surface application to control brush. **Escort 60DF** (metsulfuron) and **Telar 75DF** (chlorsulfuron) are for foliar or soil application. Arsenal, Stalker, Escort, and Telar are acetolactate-synthase (ALS) inhibitors. *Resistant biotypes of weed species such as kochia may not be controlled.*

Bromoxynil (many trade names: Buctril, Moxy, Bromox, Broclean, etc.) has contact activity against broadleaf weeds but only suppresses perennials. *Because bromoxynil is toxic to fish, observe proper precautions around water.*

Krenite S 4S (fosamine) is used for total control or side trimming of brush, depending upon the portion of the plant sprayed. When Krenite S 4S is applied within 2 months of autumn color, there is no foliar "brownout." Susceptible plants fail to refoliate the following spring.

Control of Broadleaf Weeds

Broadleaf weeds often are controlled best with foliar applications. Deep-rooted perennials can usually be controlled best when they are at the early bud or bloom stage. Some of the herbicides listed in Table 3 can move through the air and damage nearby desirable trees, shrubs, and broadleaf plants. Some of the herbicides are mobile in the soil and can damage desirable broadleaves if applied to the soil near their roots. See Table 3 or the respective product label for guidelines on appropriate rates.

Control of Undesirable Woody Plants

Most of the herbicides used to control woody plants are applied to the foliage, but many also may be applied as basal-bark treatments if the woody plants have stems smaller than 5 inches in diameter or as cut-surface (frilled) treatments if the plants are larger. Basal-bark treatments usually are applied in fuel oil. Application may be made throughout the year, even during the dormant season. Cut-surface treatments also may be made throughout the year, but the herbicides should be applied to the cut surface within 2 to 3 hours of cutting. Foliar treatments usually are applied in the spring as soon as the leaves of brush or trees have fully expanded. See Chapter 8, "Brush Control in Illinois," for more detailed information on method of application. See Table 4 for guidelines on appropriate rates and methods of application.

Weedy Grass Control

Weedy grasses can be controlled with the herbicides listed in Table 5. The use of a surfactant is labeled for some of these herbicides. Before using, read the product label carefully; some of the products listed are nonselective and kill broadleaves as well as grasses.

Contact Weed Control

Gramoxone Inteon (paraquat), **Finale** (glufosinate), and **bromoxynil** (many names) are contact herbicides requiring an adequate spray volume for complete foliar coverage. Gramoxone Inteon and Finale control annual grass and broadleaf weeds, while bromoxynil controls only broadleaf weeds. A surfactant or crop-oil concentrate is required with Gramoxone Inteon and may increase control with bromoxynil under cool, dry conditions. *Do not apply bromoxynil with backpack or handheld equipment.*

Comments

Whenever possible, use desirable plants to compete with and replace undesirable plants. For some areas, mechanical control may be the most practical and appropriate method.

Availability, formulations, trade names, and federal clearance for the use of herbicides change occasionally. Always refer to the most recent product label for precautions, directions, and application rates. Use herbicides appropriately to avoid injury to yourself and others, desirable nontarget vegetation, and the environment.

Table 3. Herbicides for broadleaf weed control

Herbicide	Rate of formulation per acre	
	Annuals and "easy to control" perennials	"Hard to control" perennials
2,4-D	1 to 2 qt	2 to 4 qt
Bromoxynil (many)	1 to 2 pt[a]	1 to 2 pt[a]
Brushmaster (2,4-D + 2,4-DP + dicamba)	2 to 4 qt	4 to 8 qt
Crossbow (triclopyr + 2,4-D)	1 to 2 qt	2 to 4 qt
Dicamba (many)	0.5 to 1 qt	1 to 2 qt
Distinct (dicamba + diflufenzopyr)[b]	4 to 6 oz	4 to 6 oz
Escort (metsulfuron)[b]	0.5 to 1 oz	1 to 3 oz
Finale 1S (glufosinate)	2 to 4 qt	4 to 6 qt
Garlon 3A (triclopyr)	2 to 3 qt	3 to 12 qt
Garlon 4/Remedy (triclopyr)	1 to 2 qt	2 to 8 qt
Glyphosate (many)	0.5 to 3 qt	3 to 5 qt
Gramoxone Inteon (paraquat)	2 to 3 pt	2 to 4 pt[a]
Oust (sulfometuron)[b]	3 to 5 oz	6 to 8 oz
Stinger, Transline (clopyralid)	0.33 to 0.5 pt	0.67 to 1.33 pt
Telar DF (chlorsulfuron)[b]	0.25 to 1 oz	1 to 3 oz
Tordon 101 Mixture (picloram + 2,4-D)	2 to 3 qt	1 to 2 gal.
Tordon K (picloram)	0.5 to 2 qt	2 qt
Weedmaster, Brash (2,4-D + dicamba)	0.5 to 4 pt	4 to 6 pt

[a]Only suppresses perennials.
[b]Note that the rate of this product is given in ounces per acre.

Table 4. Herbicides for woody plant control

Herbicide	Method of application	Rate of formulation
2,4-D ester	Foliar or basal-bark	2 to 4 qt/A
Arsenal 2AS (imazapyr)	Foliar or cut-surface	2 to 3 qt/A
Brushmaster (2,4-D + 2,4-DP + dicamba)	Foliar	1 to 2 gal./100 gal. water
Crossbow (triclopyr + 2,4-D)	Foliar	4 to 6 qt/A
	Basal-bark	1 to 4 gal./100 gal. fuel oil
Dicamba (many)	Foliar	1 to 2 qt/A
Distinct (dicamba + diflufenzopyr)	Foliar	4 to 6 oz/A
Garlon 3A (triclopyr)	Foliar or cut-surface	2 to 3 gal./A
Garlon 4/Remedy (triclopyr)	Foliar or basal-bark	4 to 8 qt/A
Glyphosate (many trade names)[a]	Foliar or cut-surface	2 to 5 qt/A
	Spot treatment	1 to 2% solution
Krenite S (4 lb/gal.)	Basal-bark	1 to 5 gal./100 gal. water
	Foliar	1.5 to 6 gal./A
Pathway (picloram + 2,4-D)	Cut-surface	Wet cambium thoroughly.
Patron 170 (2,4-D + diclorprop)	Basal-bark or cut-surface	3 to 4 gal./100 gal. spray
Stalker (2 lb/gal. imazapyr)	Basal-bark or cut-surface	8 to 16 oz/gal.; wet cambium thoroughly.
Tordon K (picloram)	Foliar	1 to 4 qt/100 gal. spray
Tordon 101 Mixture (picloram + 2,4-D)	Foliar or cut-surface	1 to 2 gal./A
	Foliar or soil	1 to 2 qt/A

[a]Glyphosate rates based on 3 lb a.e./gal. formulation.

Table 5. Herbicides for weedy grass control

	Rate of formulation per acre	
Herbicide	Annuals	Perennials
Assure II (quizalofop)	5 to 10 fl oz	12 to 16 fl oz
Glyphosate (many)[a]	0.38 to 2 qt	1 to 5 qt
Select (clethodim)	6 to 10 fl oz	8 to 16 fl oz
Vantage (sethoxydim)	2.25 to 2.5 pt	3.0 to 3.75 pt

[a]Glyphosate rates based on 3 lb a.e./gal. formulation.

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10

Application Equipment and Calibration References

Nozzle Type

Many types of spray nozzles are available, each providing different flow rates, spray angles, droplet sizes, and spray patterns. Some commonly used nozzle types are shown in Figures 1 and 2. Nozzles that produce flat-fan spray patterns are in Figure 1, and those that produce cone spray patterns are in Figure 2.

Table 1 may be used as a guideline for selecting the proper nozzle type for each application. Nozzle manufacturers often code spray nozzles to indicate specific spray characteristics. The tip number may indicate the nozzle type, flow rate, and spray-fan angle. Other characteristics are identified, with letters representing specific operating conditions. Many nozzles are now color-coded for ease of identification, and Table 2 gives the color codes used by the International Organization for Standardization (ISO).

Sprayer Calibration Guidelines

Variables Affecting Application Rate

Three variables affect the amount of spray mixture applied per acre: the nozzle flow rate, the ground speed of the sprayer, and the effective sprayed width per nozzle.

The gallons of spray applied per acre may be determined from the three variables in the following equation:

$$GPA = \frac{GPM \times 5{,}940}{MPH \times W}$$

where

GPA = spray applied, in gallons per acre

GPM = output per nozzle, in gallons per minute

MPH = ground speed, in miles per hour

W = effective sprayed width per nozzle, in inches.

For broadcast spraying, W = the nozzle spacing. For band spraying, W = the bandwidth. For row-crop applications (such as spraying from drop pipes or directed spraying), W = row spacing (or bandwidth) divided by the number of nozzles per row (or band).

5,940 = a constant to convert gallons per minute, miles per hour, and inches to gallons per acre

Selecting the Proper Nozzle Tip

The proper nozzle size may be selected by determining the required flow rate from each nozzle at a selected application rate (GPA), ground speed (MPH), and effective sprayed width (W) in inches per nozzle. The required flow rate per nozzle may be determined from the following equation:

$$GPM = \frac{GPA \times MPH \times W}{5{,}940}$$

Select a nozzle that gives the required flow rate and droplet sizes when the nozzle is operated within the recommended pressure range.

The range of droplet sizes emitted from a nozzle is called the droplet spectrum. Droplet spectra are grouped into six categories. The American Society

of Agricultural and Biological Engineers (ASABE) S572 standard, or set of rules, describes the categories as *very fine, fine, medium, coarse, very coarse,* or *extremely coarse.* These terms are listed in Table 3, along with the standard colors that are used to represent them in nozzle catalog charts. To apply pesticides using the optimum droplet size, choose nozzles based on the desired droplet spectrum category. This will help balance drift reduction with target coverage. Table 4 gives recommended droplet size spectrums for the same applications listed in Table 1.

Calibrating the Sprayer

Install the selected nozzle tips on the sprayer. Determine the flow rate for each nozzle in ounces per minute (OPM) from the following equation:

$$\text{OPM} = \text{GPM} \times 128 \text{ (1 gallon = 128 ounces)}$$

Measure the flow rate using a flow meter, or collect the output from a nozzle using a container marked in ounces. Adjust the pressure until the required GPM or OPM is collected. Check the nozzle flow rate frequently. Adjust the pressure to compensate for small changes in output resulting from nozzle wear. Replace the nozzle tips and recalibrate when the output has changed 10 percent or more from that of a new nozzle or when the pattern has become uneven.

Flow Rate

Nozzle flow rate varies with spraying pressure. The relationship between GPM and pressure (pounds per square inch, or PSI) is as follows:

$$\frac{GPM_1}{GPM_2} = \frac{\sqrt{PSI_1}}{\sqrt{PSI_2}}$$

With this relationship, doubling the flow through the nozzle requires increasing the pressure by a factor of four. The equation may be used to determine nozzle flow rates achieved at various pressures.

Example:

If a certain nozzle has a flow rate of 0.6 GPM at a pressure of 40 PSI, what would the flow rate be if the nozzle were operated at 15 PSI?

Solution:

Rearrange the formula to obtain GPM_2:

$$GPM_2 = \frac{\sqrt{PSI_2}}{\sqrt{PSI_1}} \times GPM_1$$

Solve for the new flow rate:

$$GPM_2 = \frac{\sqrt{15\ PSI}}{\sqrt{40\ PSI}} \times 0.6\ GPM$$

$$GPM_2 = \frac{3.873}{6.325} \times 0.6$$

$$GPM_2 = 0.61 \times 0.6 = 0.4$$

Effect of Solution Density on Nozzle Flow Rate

Density is the weight of a solution per unit volume (pounds per gallon). Specific gravity (SG) is the weight of a solution relative to water, which weighs 8.34 pounds per gallon. Nozzle flow rate varies inversely with the square root of specific gravity. Conversion factors to compare flow rates of solutions of any known density may be calculated as follows:

$$\text{Conversion factor} = \sqrt{SG}$$

Table 5 may be used to predict the flow rate for various solutions and to select the proper nozzle size from a nozzle catalog table. Because nozzle tables are based on spraying water, the conversion factors from the table may be multiplied by the desired GPM or GPA to determine the water flow rate for the solution being sprayed. Use the converted GPM or GPA to select the proper nozzle size from the catalog.

Example:

$$3 \text{ GPM (28\% N)} \times 1.13 = 3.39 \text{ (water)}$$

If the flow rate (GPM) or application rate (GPA) of water is known, the GPM or GPA of a solution may be predicted by dividing the flow or application rate by the conversion factor.

Example:

$$20 \text{ GPA (water)} \div 1.13 = 17.7 \text{ GPA (28\% N)}$$

Measuring Ground Speed

To measure ground speed, mark off a distance in the field to be sprayed or in a field with similar surface conditions. Suggested distances are 100 feet for speeds up to 5 miles per hour, 200 feet for speeds from 6 to 10 miles per hour, and at least 300 feet for speeds above 10 miles per hour. At the engine throttle setting and gear used for actual spraying, determine the travel time between the measured stakes. Calculate ground speed using Table 6, or apply the following formula:

$$\text{Travel speed (MPH)} = \frac{\text{distance (feet)} \times 60}{\text{time (seconds)} \times 88}$$

Spray Overlap

For uniform application, each nozzle type must be operated at a spacing and height that provide a specific spray overlap. The overlap may vary from 20 percent to more than 100 percent. The percent overlap or spray coverage is illustrated in Figure 3 and Table 7 and may be calculated from the following formulas:

$$\text{Percent overlap} = \frac{\text{spray coverage} - \text{nozzle spacing}}{\text{nozzle spacing}}$$

$$\text{Spray coverage} = (\text{nozzle spacing} \times \text{percent overlap}) + \text{nozzle spacing}$$

Spray-Angle Coverage at Various Heights

Table 8 lists the theoretical coverage of spray patterns, as calculated from the included angle of the spray and the distance from the nozzle orifice (Figure 4). These values are based on the assumption that the spray angle remains the same throughout the entire spray distance. In practice, the tabulated spray angle does not hold for long spray distances. Adjust the spray height to give proper spray overlap. Table 9 lists suggested minimal spray heights.

Nozzle Wear

Nozzle tips are available in a variety of materials, including ceramic, hardened stainless steel, stainless steel, various polymers, and brass. Ceramic and hardened stainless steel are the most wear-resistant materials but also are the most expensive. Stainless steel tips have excellent wear resistance when used with either corrosive or abrasive products. Many of the polymers are also resistant to corrosion and abrasion, and have a wear life similar to stainless steel. Polymers, however, are more sensitive to physical damage, such as can occur from improper cleaning. Brass tips wear rapidly when used to apply abrasive products such as wettable powders, and they are corroded by some liquid fertilizers.

Techniques for Reducing Spray Drift

When pesticides are applied, there is always a chance that some will escape from the target area. Although drift cannot be eliminated completely, the use of proper equipment and spraying techniques maintains drift deposits within acceptable limits. The type of nozzle, pressure, height, and spray volume all affect the off-target movement. The ability to reduce drift is no better than the weakest component in the spraying procedure. A summary of recommended procedures for minimizing spray drift is given in Table 10. Many of these procedures deal in some manner with increasing spray droplet size. Larger spray droplets are more resistant to drift.

One practice available for minimizing drift damage is the use of drift-control additives to increase the size of spray droplets. Tests indicate that downwind drift deposits are reduced from 50 to 80 percent with the use of drift-control additives. They do not eliminate drift, however, and common sense must remain the primary factor in reducing drift damage. A number of additives are commercially available; they must be mixed and applied according to label directions to be effective.

Pressure Drop Through Spraying Systems

Hoses and fittings must be selected to keep pressure drops within acceptable limits. Tables 11 to 13 give pressure drops through various sizes of hose, pipe, and coupling. The information in Table 14 is provided for reference in making any conversions needed to calibrate spray equipment properly during pesticide application.

Table 1. Recommended nozzle types for various applications made with a boom sprayer

Type of application	Extended-range flat-fan	Twin flat-fan	Pre-orifice and drift-reduction flat-fan	Turbo flat-fan	Air-induction flat-fan	Flood, turbo-flood, and high-flow	Hollow-cone
Contact insecticide and fungicide	R	HR	R	R	R	—	—
Systemic insecticide and fungicide	R	R	R	HR	HR	—	—
Postemergence contact herbicide	R	HR	R	R	R	—	—
Postemergence systemic herbicide	R	—	R	HR	HR	R	—
Preemergence herbicide	—	—	R	R	R	HR	—
Incorporated soil-applied pesticide	—	—	R	R	R	HR	—

HR denotes that nozzle type is highly recommended for this application.
R denotes that nozzle type is recommended for this application.
— denotes that nozzle type is not recommended for this application.

Table 2. ISO 10625 nozzle colors

Flow rate at 40 PSI, gal./min*	Flow rate at 300 kPa, L/min	Color
0.1	0.4	Orange
0.15	0.6	Green
0.2	0.8	Yellow
0.3	1.2	Blue
0.4	1.6	Red
0.5	2.0	Brown
0.6	2.4	Gray
0.8	3.2	White

*Metric is the standard. Equivalent U.S. units are approximations only.

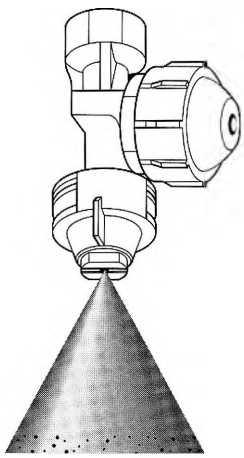
Table 3. ASABE S572 classification by droplet spectra

Classification category	Symbol	Color code (in catalog tables)
Very fine	VF	Red
Fine	F	Orange
Medium	M	Yellow
Coarse	C	Blue
Very coarse	VC	Green
Extremely coarse	XC	White

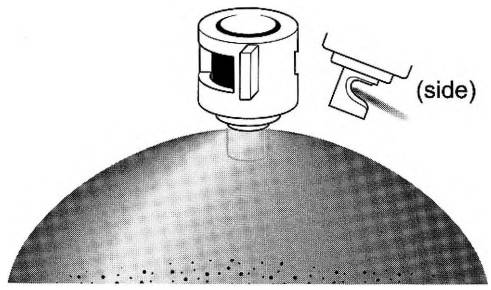
Table 4. Droplet size spectra recommended for various pesticide uses

Droplet spectrum (by ASABE S572)	Contact insecticide and fungicide	Systemic insecticide and fungicide	Postemergence contact herbicide	Postemergence systemic herbicide	Preemergence herbicide	Incorporated soil-applied pesticide
Very fine (VF)	..	..	..	..	..	..
Fine (F)	X	..	..	..	..	..
Medium (M)	X	X	X	X	..	..
Coarse (C)	..	X	..	X	X	X
Very coarse (VC)	..	..	..	..	X	X
Extremely coarse (XC)	..	..	..	..	..	X

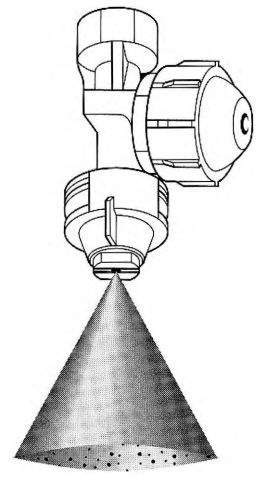
X denotes that droplet size spectrum is recommended for this application.
.. denotes that droplet size spectrum is not recommended for this application.



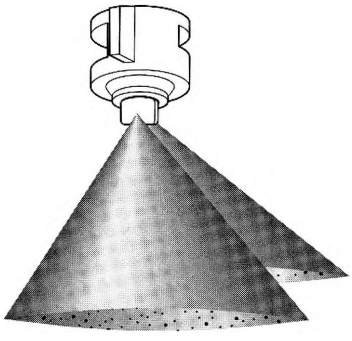
Even Flat-Fan



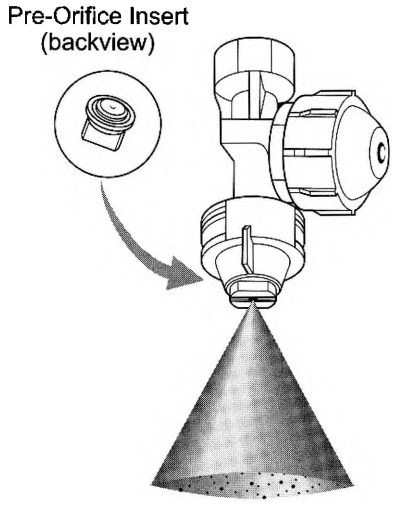
Flooding Flat-Fan (front)



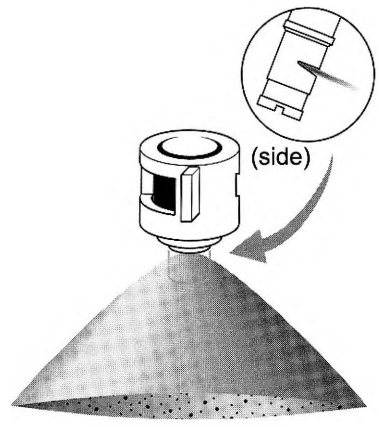
Extended-Range Flat-Fan



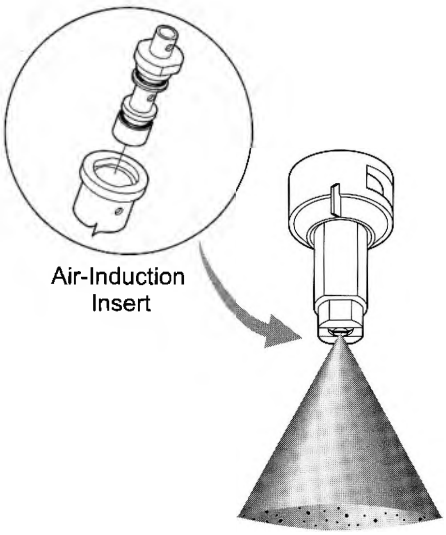
Twin-Orifice Flat-Fan



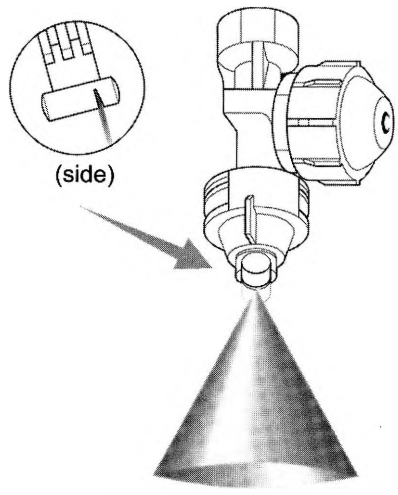
Drift-Reduction Pre-Orifice Flat-Fan



Turbo-Flood Flat-Fan



Air-Induction Flat-Fan



Turbo Flat-Fan (front)

Figure 1. Spray nozzles that produce flat-fan spray patterns.

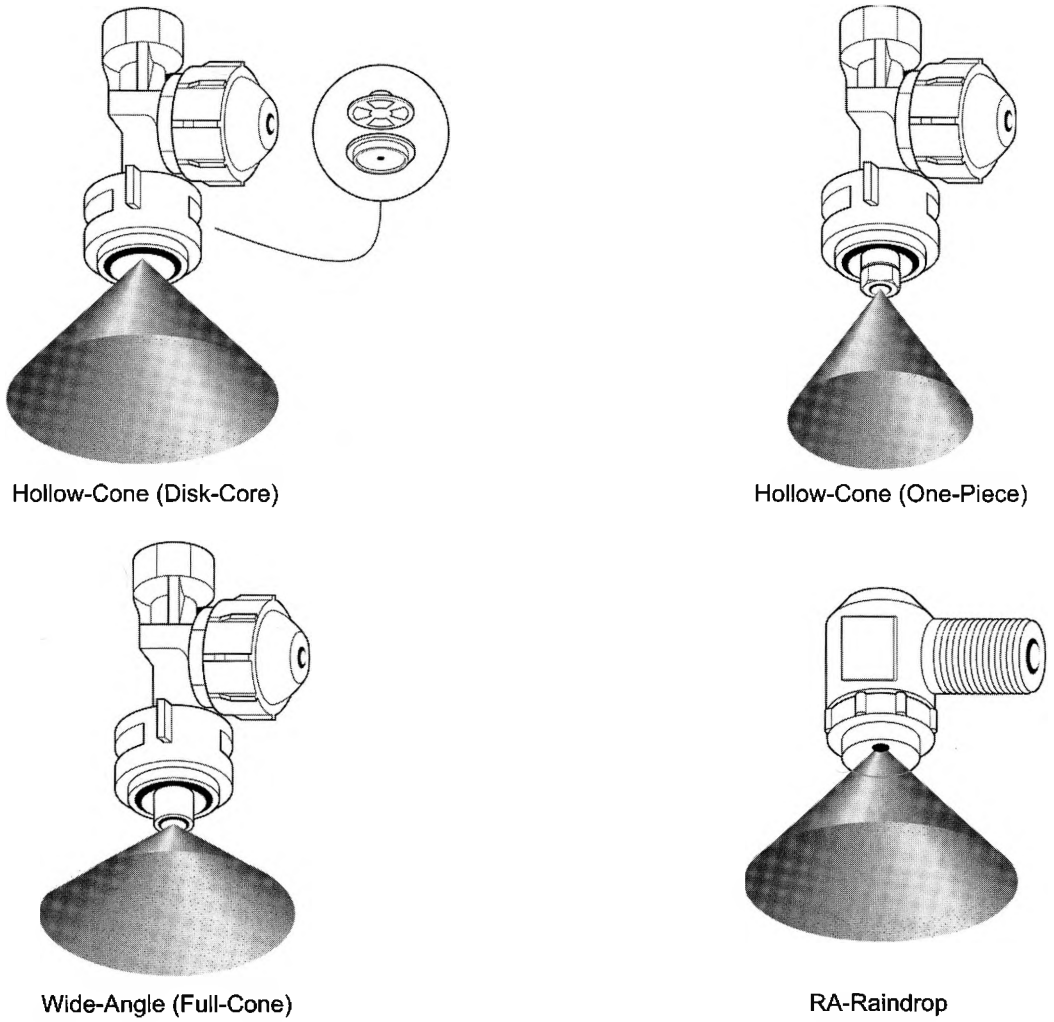


Figure 2. Spray nozzles that produce cone spray patterns.

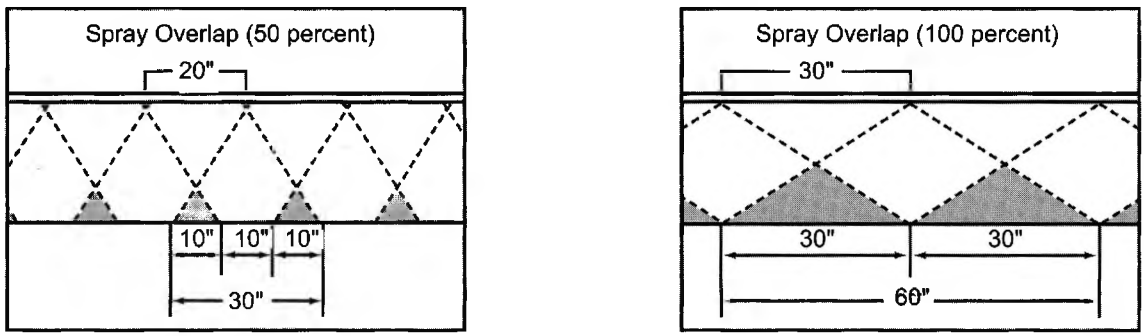


Figure 3. Examples of 50 percent and 100 percent spray overlap.

Table 5. Specific gravities and conversion factors for selected solution weights

Solution weight, lb/gal.	Specific gravity	Conversion factor
7.0	0.84	0.92
8.0	0.96	0.98
8.34[a]	1.00	1.00
9.0	1.08	1.04
10.0	1.20	1.10
10.65[b]	1.28	1.13
11.0	1.32	1.15
12.0	1.44	1.20
14.0	1.68	1.30

NOTE: This table is based on theoretical solution densities only and may vary in actual practice because of differing solution characteristics. Figures apply to flood but not Raindrop nozzles.
[a]Water.
[b]28% nitrogen.

Table 6. Time required to obtain various travel speeds

	Travel time, seconds		
Speed, MPH	100 ft	200 ft	300 ft
3.0	23	45	68
3.5	20	39	58
4.0	17	34	51
4.5	15	30	45
5.0	14	27	41
6.0		23	34
7.0		19	29
8.0		17	26
9.0		15	23
10.0		14	20
11.0			19
12.0			17
13.0			16
14.0			15
15.0			14

Table 7. Spray coverage required to obtain proper overlap of spray patterns

	Spray coverage (width of spray pattern) in inches at various nozzle spacings						
Overlap (%)	20"	25"	30"	35"	40"	50"	60"
20	24	30	36	42	48	60	72
30	26	33	39	46	52	65	78
40	28	35	42	49	56	70	84
50	30	38	45	53	60	75	90
60	32	40	48	56	64	80	96
70	34	43	51	60	68	85	102
80	36	45	54	63	72	90	108
90	38	48	57	67	76	95	114
100	40	50	60	70	80	100	120
110	42	53	63	74	84	105	126
150	50	63	75	88	100	125	150

Table 8. Computed spray coverage at different spray heights for various spray angles

Spray angle, degrees	Spray coverage (width of spray pattern) in inches at various distances from nozzle orifice										
	6"	8"	12"	15"	18"	24"	30"	36"	42"	48"	60"
15	1.6	2.1	3.2	3.9	4.7	6.3	7.9	9.5	11.1	12.6	15.8
25	2.7	3.5	5.3	6.6	8.0	10.6	13.3	15.9	18.6	21.2	26.6
30	3.2	4.3	6.4	8.0	9.7	12.8	16.0	19.3	22.4	25.9	32.0
40	4.3	5.8	8.7	10.9	13.0	17.4	21.6	26.2	30.6	34.9	42.8
45	4.9	6.6	9.9	12.4	14.9	19.8	24.8	29.8	34.8	39.7	49.6
50	5.6	7.4	11.2	14.0	16.8	22.4	28.0	33.6	39.1	44.8	56.0
60	6.9	9.2	13.9	17.3	20.8	27.6	34.6	41.6	48.4	55.4	69.2
65	7.6	10.2	15.2	19.1	22.9	30.5	38.1	45.8	53.2	61.0	76.4
70	8.2	11.2	16.8	21.0	25.2	33.6	42.0	50.4	59.8	67.2	84.0
73	8.8	11.8	17.8	22.2	26.6	36.4	44.4	53.2	62.0	71.0	88.5
75	9.2	12.3	18.4	23.0	27.6	36.8	46.0	55.2	64.2	73.5	92.0
80	10.1	13.4	20.1	25.2	30.2	40.2	50.2	60.4	72.5	80.8	100.0
90	12.0	16.0	24.0	30.0	36.0	48.0	60.0	72.0	84.0	96.0	120.0
100	14.3	19.1	28.6	35.8	42.4	57.2	71.4	86.0	100.0	114.6	143.0
120	20.8	27.8	41.6	52.0	62.4	83.0	104.0	125.0	145.8	166.2	208.0
140	33.0	44.0	65.9	82.4	98.9	131.9	164.8	197.8	230.8	263.8	329.7

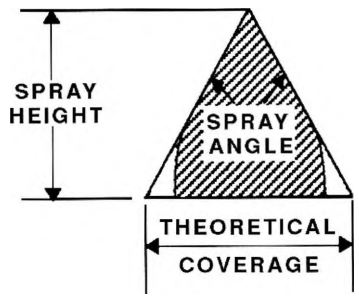


Figure 4. Theoretical coverage of spray pattern.

Table 9. Suggested minimal spray heights for given angles of flat-fan nozzles

Spray angle	20-inch spacing	30-inch spacing
65°	22" to 24"	33" to 36"
73°	20" to 22"	29" to 36"
80°	18" to 20"	26" to 28"
110°	16" to 18"	20" to 22"
120°	14" to 16"	18" to 20"

Table 10. Summary of recommended procedures for reducing drift damage

Recommended procedure	Example	Explanation
Select a nozzle type that produces coarse droplets.	Turbo, air-induction, Raindrop, wide-angle full-cone, flooding.	Use droplets as large as practical to provide necessary coverage.
Use the lower end of the pressure range.	Use less than 30 PSI for extended-range flat-fan nozzles.	Higher pressures generate many more small droplets (less than 100 microns).
Lower the boom height.	Use as low a boom height as possible to maintain uniform distribution. Use drops for systemic herbicides in corn.	Wind speed increases with height. Boom height a few inches lower can reduce off-target drift.
Increase the nozzle size.	If normal gallonage is 15 to 20 GPA, increase to 25 to 30 GPA.	Larger-capacity nozzles reduce spray depositing off target.
Spray when wind speeds are less than 10 MPH and moving away from sensitive plants.	Leave a buffer zone if sensitive plants are downwind. Spray buffer zone when wind changes.	More of the spray volume moves off target as wind increases.
Do not spray when the air is completely calm.	Absolutely calm air generally occurs in early morning or late afternoon.	Absolutely calm air reduces air mixing, and spray can move slowly downwind.
Use a drift-control additive when needed.	Several long-chain polymers are available.	Drift-control additives increase the average droplet size produced by the nozzles.

Table 11. Pressure drop for water flow through various hose sizes (in good, smooth condition)

	Pressure drop in pounds per square inch (10-foot lengths—without couplings)								
Flow, GPM	¼" ID	⅜" ID	7/16" ID	½" ID	⅝" ID	¾" ID	1" ID	1¼" ID	1½" ID
0.2	0.3								
0.3	0.6								
0.4	1.0								
0.5	1.4	0.2							
0.6	2.0	0.3							
0.8	3.3	0.5							
1.0		0.7	0.3						
1.5		1.4	0.6	0.4					
2.0		2.4	1.1	0.6					
2.5		3.4	1.7	0.9					
3.0			2.4	1.2	0.4				
4.0				2.0	0.7				
5.0				2.9	1.0	0.4			
6.0				4.0	1.4	0.6			
8.0					2.6	0.9	0.3		
10					3.6	1.4	0.4		
15						3.0	0.8	0.3	
20							1.4	0.5	0.2
25							2.0	0.7	0.3
30							2.8	0.9	0.4
40								1.6	0.5
50								2.5	0.8
60								3.4	1.2
70									1.6
80									2.0
90									2.6
100									3.0

ID = inside diameter.

Table 12. Flow of water through schedule 40 steel pipe of various sizes (seamless or welded construction in good, clean condition)

	Pressure drop in pounds per square inch (10-foot lengths)								
Flow, GPM	⅛" ID	¼" ID	⅜" ID	½" ID	¾" ID	1" ID	1¼" ID	1½" ID	2" ID
0.3	0.42								
0.4	0.70	0.16							
0.5	1.1	0.24							
0.6	1.5	0.33							
0.8	2.5	0.54	0.13						
1.0	3.7	0.83	0.19	0.06					
1.5	8.0	1.8	0.40	0.12					
2.0	13.4	3.0	0.66	0.21	0.05				
2.5		4.5	1.0	0.32	0.08				
3.0		6.4	1.4	0.43	0.11				
4.0		11.1	2.4	0.74	0.18	0.06			
5.0			3.7	1.1	0.28	0.08			
6.0			5.2	1.6	0.38	0.12			
8.0			9.1	2.8	0.66	0.20	0.05		
10				4.2	1.0	0.30	0.08		
15					2.2	0.64	0.16	0.08	
20					3.8	1.1	0.28	0.13	
25						1.7	0.42	0.19	0.06
30						2.4	0.59	0.27	0.08
35								0.36	0.11
40								0.47	0.14
45									0.17
50									0.20
60									0.29
70									0.38
80									0.50
90									0.62
100									0.76

ID = inside diameter.

Table 13. Approximate friction loss in pipe fittings in terms of equivalent feet of straight pipe

Pipe size, standard weight	Actual inside diameter, inches	Gate value FULL OPEN	Globe value FULL OPEN	45° elbow	Run or standard tee	Standard elbow or run of tee reduced ½	Standard tee through side outlet
⅛	0.269	0.1	8	0.3	0.4	0.7	1.4
¼	0.364	0.2	11	0.5	0.6	1.1	2.2
½	0.622	0.3	18	0.7	1.1	1.7	3.3
¾	0.824	0.4	23	0.9	1.4	2.1	4.2
1	1.049	0.5	29	1.2	1.8	2.6	5.3
1¼	1.380	0.7	38	1.6	2.3	3.5	7.0
1½	1.610	0.8	45	1.9	2.7	4.1	8.1
2	2.067	1.1	58	2.4	3.5	5.2	10.4
2½	2.469	1.3	69	2.9	4.2	6.2	12.4
3	3.068	1.6	86	3.6	5.2	7.7	15.5
4	4.026	2.1	113	4.7	6.8	10.2	20.3
5	5.047	2.7	142	5.9	8.5	12.7	25.4
6	6.065	3.2	170	7.1	10.2	15.3	31.0

Table 14. Reference information for making calibration conversions

Standard Abbreviations

GPA = gallons per acre
GPM = gallons per minute
GPH = gallons per hour
MPH = miles per hour
OPM = ounces per minute
PSI = pounds per square inch

Volume and Liquid Measures

8 fluid ounces = 1 cup = 236.6 ml

2 cups = 32 tablespoons = 1 pint = 473.1 ml

2 pints = 64 tablespoons = 1 quart = 946.2 ml

8 pints = 4 quarts = 1 gallon =
128 fluid ounces = 3,785 ml

Miscellaneous Equivalents

1 acre = 43,560 square feet = 0.405 hectares

1 hectare = 2.471 acres

1 gallon per acre = 9.35 liters per hectare

1 mile = 5,280 feet = 1,610 meters =
1.61 kilometers

1 pound per square inch =
0.070 kilogram/centimeter^2 = 6.895 kilopascals

1 pound = 0.454 kilogram

1 inch = 2.54 centimeters

Metric Conversion Factors

During the next few years, a gradual transition to metric (SI) units is expected in the agricultural industry. To facilitate use of these units, selected metric terms and conversion factors are given here.

To measure	Multiply	By	To obtain
Length	inches	25.40	millimeters (mm)
	inches	2.540	centimeters (cm)
	feet	0.3048	meters (m)
	miles	1.609	kilometers (km)
Area	acres	46.7	square meters (m^2)
	acres	0.4047	hectares (ha)
Volume	gallons	3.785	cubic decimeters (dm^3)
	gallons	3.785	liters (L)
	imperial gallons	4.546	liters (L)
Flow rate	gallons/hour (GPH)	3.785	liters/hour (L/h)
	gallons/minute (GPM)	3.785	liters/minute (L/min)
Application rate	gallons/acre (GPA)	9.353	liters/hectare (L/ha)
Pressure	pounds/inch^2 (PSI)	6.895	kilopascals (kPa)
Speed	miles/hour (MPH)	1.609	kilometers/hour (KMH)

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11

Toxicity of Herbicides

Toxicity is the capacity of a substance to produce injury. Toxic effects may be immediate (acute) or accumulative (chronic), depending upon the exposure duration, the dose, and the herbicide. The toxicity of a substance varies with the animal species, age, sex, and nutritional status and with the route of exposure—through the stomach (orally), the lungs (by inhalation), or the skin (dermally). The skin and eyes are also subject to irritation caused by chemicals.

Human Toxicity of Herbicides

Pesticide manufacturers are required to conduct acute, subacute, and chronic toxicity tests, including tests for mutagenicity, teratogenicity, and carcinogenicity. The usual expression of acute toxicity is LD_{50}, which is the average lethal dose in milligrams per body weight in kilograms (mg/kg) required to kill 50 percent of a test population. Toxicity tests are conducted on experimental animals, such as white rats, mice, and rabbits.

To make mg/kg more meaningful, the following factors are given to convert mg/kg to ounces per pound (oz/lb) for a 100-pound person and a 187-pound person:

mg/kg x 0.0016 = oz/100 lb
mg/kg x 0.0030 = oz/187 lb

Because toxicity depends upon body weight, the amount of chemical considered lethal for a child is less than the amount for an adult. And conversely, it takes more to kill a large animal than a small one.

The categories of toxicity are given in Table 1. The herbicide label indicates the extent of toxicity by the signal word(s) it carries. The signal word on the label applies to the most serious method or route of exposure. For example, if an herbicide has an acute oral LD_{50} of 368 (which triggers the signal word "Warning") and an acute dermal LD_{50} of > 2,000 (which triggers "Caution") and is severely and irreversibly corrosive to the eyes (which warrants "Danger"), then the label signal word is "Danger."

Danger–Poison

Herbicides with the active ingredient endothall or paraquat carry the signal word "Danger" plus a skull and crossbones. Endothall is available in liquid form as Aquathol K and Hydrothol 191. Paraquat is available as Gramoxone Inteon.

These herbicide labels carry the following precautions: The user is advised to wear goggles or a face shield, rubber gloves, and a rubber apron when working with concentrates and to avoid breathing spray mists.

Danger–Corrosive

The signal words "Danger–Corrosive" indicate the risk of irreversible eye or skin burns. This warning is usually accompanied by a recommendation that the user wear goggles or a face shield, especially when handling concentrates. The label also may call for wearing rubber gloves and an apron when handling or mixing concentrates or adjusting equipment. The first-aid statement states, "In case of contact with eyes, immediately flush eyes with plenty of water for at least 15 minutes and **get medical attention promptly.**" If the contact is with the skin, the label calls for washing with plenty of water. If skin irrita-

The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.

Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.

Table 1. Toxicity categories of herbicides

Toxicity category	Label signal words	Skin effects	Acute oral LD_{50} (mg/kg)	Acute dermal LD_{50} (mg/kg)	Acute inhalation LC_{50}* (mg/L)
I. High	Danger–Poison	corrosive	≤ 50	≤ 200	≤ 0.2
II. Moderate	Warning	severe irritation at 72 hours	50–500	200–2,000	0.2–2
III. Low	Caution	moderate irritation at 72 hours	500–5,000	2,000–20,000	2–20
IV. Very low	Caution	mild irritation at 72 hours	> 5,000	> 20,000	> 20

*LC_{50} = concentration of pesticide, in milligrams per liter of air space, required to kill 50 percent of a test population.

tion occurs, medical attention should be sought. Herbicides in this category are listed in Table 2.

WARNING

"Warning" is the signal word used for herbicides containing an active ingredient that is moderately toxic through oral, dermal, or inhalation exposure. The labels state, under "Hazardous to Humans," "May be fatal or harmful if swallowed, inhaled, or absorbed through the skin." The following herbicides contain such a warning:

Bromoxynil
Buctril 2EC, Buctril + atrazine, Moxy, etc.

Diquat
Reward, Weedtrine-D

Glufosinate
Liberty

"Warning" also appears as a signal word for herbicides with label statements indicating that they can cause eye or skin irritation or burns or may be harmful if swallowed, inhaled, or absorbed through the skin. Herbicides in this category are listed in Table 3.

Most of these herbicide labels state, "Do not get into eyes or on skin." If skin or eye contact occurs, the labels advise washing the contacted areas thoroughly for 15 minutes and calling a physician in case of eye contact. All herbicide labels must include a section describing the appropriate personal protective equipment that should be worn by applicators and handlers.

Any herbicide that does not have a "Danger" or "Warning" signal word has "Caution" on the label. "Caution" indicates that the product has low oral, dermal, and inhalation toxicity and has little or no irritability to either the eyes or the skin.

Table 2. Herbicides labeled with the signal words "Danger–Corrosive" or "Danger–Poison"

Trade name	Common name
Aquathol	endothall
Assure II	quizalofop
Butoxone 200	2,4-DB amine
Butyrac 200	2,4-DB amine
Cimarron Max	metsulfuron + dicamba + 2,4-D
Cobra	lactofen
Confront	triclopyr + clopyralid
Curtail	clopyralid + 2,4-D
Devrinol 2E	napropamide
Garlon 3A	triclopyramine
Gramoxone Inteon	paraquat
Hydrothol 191	endothall
IntRRo	alachlor
Laddok S-12	bentazon + atrazine
Many	2,4-D amine
MCPA Amine	MCPA
Reflex	fomesafen
Shotgun	atrazine + 2,4-D
Sonalan (HFP or 10G)	ethalfluralin
Storm	acifluorfen + bentazon
Ultra Blazer	acifluorfen
Velpar L	hexazinone
Weedone 638	2,4-D acid + ester

Table 3. Herbicides labeled with the signal word "Warning"

Trade name	Common name
Alanap-L	naptalam
Banvel, Sterling	dicamba
Buctril, Moxy, Bromox, etc.	bromoxynil
Camix	*S*-metolachlor + mesotrione
Define DF	flufenacet
Extreme	imazethapyr + glyphosate
Flexstar	fomesafen
G-Max Lite	dimethenamid-P + atrazine
Goal	oxyfluorfen
Harness	acetochlor + safener
Hornet WDG	flumetsulam + clopyralid
Liberty	glufosinate
Lightning	imazethapyr + imazapyr
MCPA esters	MCPA
Outlook	dimethenamid-P
Poast	sethoxydim
Pramitol	prometon
Pursuit DG	imazethapyr
Resource	flumiclorac
Reward, Weedtrine-D	diquat
Ronstar	oxadiazon
Select, Select Max	clethodim
Starane	fluroxypyr
Super Brush	2,4-D + dicamba + dichlorprop
Surpass	acetochlor

Environmental Toxicity of Herbicides

The "Environmental Hazards" section of the label includes statements regarding toxicity to fish and wildlife, and the user is urged to be especially careful in this regard. Herbicides that state they are toxic to fish or wildlife contain the active ingredient bromoxynil, propachlor, or others:

Bromoxynil
- Buctril 2EC, Moxy, Bromox, etc.
- Buctril + atrazine

Others
- Goal (oxyfluorfen)
- Gramoxone Inteon (paraquat)
- Reward, Weedtrine-D (diquat)

Some herbicide labels carry the statement "Toxic to Fish." These include certain esters of phenoxy and pyridinoxy-phenoxy herbicides, the dinitroaniline herbicides, and miscellaneous others. All herbicide labels warn the user to keep the product out of lakes and streams.

Dinitroanilines (DNAs)
- Balan (benefin)
- Prowl, Pendimax (pendimethalin)
- Sonalan, Curbit (ethalfluralin)
- Many (trifluralin)

DNA mixes
- Pursuit Plus (pendimethalin + imazethapyr)

Oxy-phenoxy esters
- Fusilade DX 2EC (fluazifop)
- Fusion 2.56EC (fluazifop + fenoxaprop)

Phenoxy esters

(There are many phenoxy herbicide products.)
- Crossbow 3EC
- Esteron 99
- Garlon 4E
- MCPA ester
- Patron 170

Other herbicides, such as **Aim** (carfentrazone), contain warnings stating that they are very toxic to algae and moderately toxic to fish. The potential for contaminating groundwater with pesticides has prompted the addition of groundwater statements on several pesticide labels, especially for products containing atrazine, simazine, flufenacet, dimethenamid, acetochlor, alachlor, metolachlor, or metribuzin. Table 4 lists herbicides carrying label statements cautioning the user to handle the herbicides in a manner that minimizes the potential for groundwater contamination.

Table 4. Herbicides carrying label statements about groundwater contamination

Trade name	Common name	Trade name	Common name
2,4-D Amine (many)	2,4-D Amine	Keystone, Keystone LA	acetochlor + atrazine
AAtrex, Atrazine	atrazine	Krovar	bromacil + diuron
Authority MTZ	sufentrazone +metribuzin	Laddok S-12	atrazine + bentazon
Balance Pro	isoxaflutole	Lightning	imazethapyr + imazapyr
Banvel	dicamba	Lumax, Lexar	*S*-metolachlor + atrazine + mesotrione
Basagran	bentazon		
Bicep II Magnum, Bicep Lite II Magnum	*S*-metolachlor + atrazine	Marksman	dicamba + atrazine
		Micro-Tech	alachlor
Boundary	*S*-metolachlor + metribuzin	Northstar	primisulfuron + dicamba
Breakfree	acetochlor	Outlook	dimethenamid-P
Breakfree ATZ	acetochlor + atrazine	Paramount	quinclorac
Buctril + atrazine	bromoxynil + atrazine	Pathway	picloram + 2,4-D
Camix	*S*-metolachlor + mesotrione	Prefix	*S*-metolachlor + fomesafen
Celebrity Plus	nicosulfuron + dicamba + diflufenzopyr	Princep	simazine
		Python	flumetsulam
Clarity	dicamba	Radius	flufenacet + isoxaflutole
Define	flufenacet	Sencor	metribuzin
Degree	acetochlor	Sequence	*S*-metolachlor + glyphosate
Degree Xtra	acetochlor + atrazine	Shotgun	atrazine + 2,4-D
Distinct, Status	dicamba + diflufenzopyr	Sim-Trol	simazine
Dual II Magnum	*S*-metolachlor	Sonic, Authority First	cloransulam + sulfentrazone
Expert	*S*-metolachlor + atrazine + glyphosate	Spartan	sulfentrazone
		Spirit	primisulfuron + prosulfuron
FieldMaster	acetochlor + atrazine + glyphosate	Steadfast ATZ	nicosulfuron + rimsulfuron + atrazine
FirstRate	cloransulam	Stinger	clopyralid
FulTime	acetochlor + atrazine	Storm	bentazon + acifluorfen
G-Max Lite, Guardsman Max	dimethenamid-P + atrazine	SureStart	acetochlor + flumetsulam + clopyralid
		Surpass	
Halex GT	*S*-metolachlor +glyposate + mesotrione	TopNotch	acetochlor
		Tordon 101	acetochlor
Harness	acetochlor	Tordon K	picloram + 2,4-D
Harness Xtra	acetochlor + atrazine	Tordon RTU	picloram
Hornet WDG	flumetsulam + clopyralid	Ultra Blazer	picloram + 2,4-D
Hyvar X, XL	bromacil	Yukon	acifluorfen
IntRRo	alachlor		

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Weed Resistance to Herbicides

Herbicide-resistant weed biotypes continue to plague farmers across much of Illinois. Biotypes are populations within a species that possess characteristics not common to the species as a whole. In this case, the "uncommon characteristic" is resistance to a particular herbicide. Understanding how herbicide resistance develops is an important initial step in designing effective weed-management strategies that deter the selection for resistant biotypes. Table 1 provides a listing of weed species in Illinois that have biotypes resistant to particular herbicide families.

The occurrence of herbicide-resistant weeds has increased during the past decade, but the first reports of herbicide-resistant weeds were documented as early as the 1950s, when dandelion and wild carrot biotypes were reported to be resistant to 2,4-D. Triazine-resistant common groundsel was first reported in 1968 in Washington. Worldwide, more than 183 weed species have been reported to possess resistance to one family of herbicides or another.

The terminology used when discussing herbicide resistance can be confusing. The most common terms are defined as follows:

Herbicide resistance: Resistance is the inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type.

Herbicide tolerance: Tolerance is the inherent ability of a species to survive and reproduce after herbicide treatment.

Let's examine these definitions more closely. Notice in the definition of resistance, the word "plant" is used, whereas "species" is used in the definition of tolerance. Stated another way, a resistant plant is a member of a species that, as a whole, is susceptible to the herbicide. The resistant plant is a **biotype** of that species that is no longer susceptible to the herbicide. Tolerance implies the species has never been susceptible to the herbicide.

Other terms related to herbicide resistance include the following:

Cross-resistance: Resistance to a herbicide the plant may not have been previously exposed to but that has a mode or site of action similar to the original herbicide.

Multiple-resistance: Resistance to more than one class of herbicides with very different modes or sites of action in which more than one basis for resistance may be involved.

The following examples may help to eliminate confusion about these terms. A producer who has grown continuous corn on the same field for many years has used atrazine (a photosynthesis-inhibiting herbicide) each year for weed control. He or she notices that in recent years the control of common lambsquarters has been poor. The local Extension educator collects seed from the common lambsquarters and, during the winter, confirms that the weed is **resistant** to atrazine. The producer then decides to switch to simazine (another photosynthesis inhibitor) the following year and again finds the control of common lambsquarters to be poor. Further investigation reveals that the common lambsquarters is also resistant to simazine. Because the plants are resistant to both atrazine and simazine, they are said to exhibit **cross-resistance**. The next year, the producer decides to use a post-emergence application of Clarity (a growth-regulating herbicide) to control the common lambsquarters, and

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The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.

Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.

once again poor control results. Investigations reveal that the common lambsquarters is also resistant to Clarity, a situation that is defined as **multiple-resistance**. A documented example of multiple-resistance is a biotype of waterhemp from western Illinois. This biotype has demonstrated resistance to such herbicide families as the acetolactate synthase (ALS) inhibitors, triazines (atrazine, simazine), and protoporphyrinogen oxidase (PPO) inhibitors. If these forms of resistance were ranked from least difficult to most difficult to control with herbicides, the order would be resistant < cross-resistant < multiple-resistant.

Origin of Resistance

To slow the selection of herbicide-resistant weeds, one should have a basic understanding of how a resistant weed population develops. Two mechanisms have been proposed: the mutation theory and the natural-selection theory.

The mutation theory postulates that a genetic mutation occurs within a plant following the application of a herbicide and that this mutation confers resistance to the plant. There is little evidence to support this theory, and it is disregarded by most scientists as a valid explanation for the development of resistance to herbicides.

The natural-selection theory is widely regarded as the most plausible explanation for the development of resistance. The theory states that herbicide-resistant biotypes have always existed at extremely low numbers within particular weed species. When a herbicide effectively controls the majority of susceptible members of a species, only those plants that possess a resistance trait can survive and produce seed for future generations.

This theory of resistance development has several parallels to Darwin's theory of survival of the fittest. Biological organisms (humans, plants, animals, etc.) exhibit a wide range of diversity. No two people are exactly the same, and plants likewise show extreme diversity. The plants that are in a population with characteristics enabling them to survive under a wide range of environmental and other adverse conditions will be the ones to produce seed that maintains these survival characteristics. The plants less adapted do not survive, and hence only the fittest plants produce seed. Plants that possess characteristics (such as resistance to herbicides) that are not common to the entire species are referred to as "biotypes." The characteristics possessed by resistant biotypes that confirm herbicide resistance will be presented later in the chapter.

What then is meant by "selection pressure" in regard to herbicide-resistant weeds? Herbicides are used to control a wide spectrum of weeds. By controlling susceptible members of a weed population, we are essentially using herbicides as agents to select for biotypes that are naturally resistant to the herbicide. When most of the susceptible members of a weed population are controlled, the resistant biotypes are able to continue growing and eventually produce seed. The seed from the resistant biotypes ensures that the resistance trait carries into future seasons. If the same herbicide is used year after year, or several times during a single season, the resistant biotypes continue to thrive, eventually outnumbering the normal (susceptible) population. In other words, relying on the same herbicide (or herbicides with the same site of action) for weed control creates selection pressure that favors the development of herbicide-resistant weeds.

The development of a herbicide-resistant weed population can be summarized by the following principle: *The appearance of herbicide-resistant weeds is the consequence of using a herbicide with a single site of action year after year or of repeating applications of a herbicide during the growing season to kill a specific weed species not controlled by any other herbicide or in any other manner.* This principle has three key components:

1. A herbicide with a single site of action.
2. Repeated use of the same herbicide.
3. The absence of other control measures.

By understanding these components and developing weed-control systems with them in mind, producers can greatly reduce the probability that herbicide-resistant weeds will develop in their fields.

Basis for Weed Resistance

What occurs within a resistant plant that allows it to survive after a herbicide application? What characteristics do the resistant plants possess that the susceptible plants lack? Two mechanisms have been identified that account for the majority of observed cases of herbicide resistance:

1. **Alterations in the target site of the herbicide.** A herbicide has a specific site within the plant where it acts to disrupt a particular plant process or function. If this target site is somewhat altered, the herbicide molecule may be unable to exert its phytotoxic action effectively. Thus far, most cases of herbicide resistance have involved alterations in the herbicide target site. Examples include resistance to triazine (atrazine, simazine, and others), ALS-inhibiting herbicides (imazaquin, chlorsulfuron, and others), and ACCase-inhibiting herbicides (sethoxydim, fenoxaprop, and others).

2. **Enhanced metabolism of the herbicide.** Metabolism within the plant is one mechanism a plant uses to detoxify a foreign compound such as a herbicide. A weed with an enhanced ability to metabolize a herbicide can potentially inactivate it before it can reach its site of action within the plant. A triazine-resistant biotype of velvetleaf from Maryland has been identified that possesses an enhanced ability to metabolize the herbicides atrazine and simazine. Generally, as stated earlier, weed resistance to triazine herbicides is attributed to alterations in the target site of the herbicide. This velvetleaf biotype, however, possesses an enhanced enzyme activity that rapidly metabolizes the herbicide to nonphytotoxic forms.

Management Strategies to Minimize Herbicide-Resistant Weeds

The best solution for minimizing herbicide-resistant weeds is to prevent their selection. In the past, as new weed problems were discovered, the usual solution has been to develop new herbicides. Today, the high cost of developing a new herbicide makes good management practices the best method for dealing with herbicide-resistant weeds. The following management strategies may help deter the development of herbicide resistance:

- Scout fields regularly to identify resistant weeds. Respond quickly to changes in weed populations to restrict the spread of plants that may have developed resistance.
- Rotate herbicides with different sites of action. Do not make more than two consecutive applications of herbicides with the same site of action against the same weed unless other effective control practices are included in the management system. Consecutive applications can be single applications in 2 years or two split applications in 1 year.
- Apply herbicides in tank-mixed, prepackaged, or sequential mixtures that include multiple sites of action. Both herbicides in the mixture must have substantial activity against potentially resistant weeds, as well as similar soil persistence.
- As new herbicide-resistant and herbicide-tolerant crops become available, their use should still not result in more than two consecutive applications of herbicides with the same site of action against the same weed unless other effective practices are included in the management system.
- Combine mechanical control practices (such as rotary hoeing, cultivating, and even hand weeding) with herbicide treatments for a near-total weed-control program.
- Clean tillage and harvest equipment before moving from fields infested with resistant weeds to fields that are not infested.
- Railroads, public utilities, highway departments, and similar organizations using total-vegetation-control programs should be encouraged to use practices that do not lead to the development of herbicide-resistant weeds. Resistant weeds resulting from areas of total vegetation control frequently spread to cropland. Chemical companies, state and federal agencies, and farm organizations can help in this effort.

Several criteria may be used to diagnose a herbicide-resistant weed problem correctly:

- All other causes of herbicide failure have been eliminated.
- Other weeds on the herbicide label (besides the one in question) were controlled effectively.
- The field has a history of continuous or repeated use of the same herbicide or herbicides with the same site of action.
- The weed species was controlled effectively in the past. Weed control in the field has been based entirely on herbicides without mechanical control.

With these management strategies and diagnosis criteria in mind, how does one go about correctly identifying a resistant weed population? We know that initially resistant weed biotypes are present at extremely low frequencies within a particular population. It stands to reason, then, that because of such a low initial frequency, resistance will most likely be first noticed within a particular field as a few individual weeds that were not controlled. In other words, resistant weeds do not usually infest an entire field within 1 year. Typically, the resistant weed population is initially confined to small, isolated patches. If the same herbicide-control program is followed repeatedly, these patches begin to encompass a larger proportion of the field until finally the resistant weeds appear as the dominant species. So a producer who encounters an entire field of resistant weeds has most likely had a resistant population in the field for more than 1 year.

How can the spread of resistant weeds be confined? Early identification of the problem, using the information provided in this chapter, ultimately proves beneficial. A hypothetical scenario may help put all these pieces of the resistance puzzle together.

A producer has grown continuous corn for the last 10 years on a particular 40-acre farm, using atrazine at the highest allowable rate each year to control broadleaf weeds. While scouting this field during the growing season, the producer notices several lambsquarters in a small patch (say 30 feet in diameter) but observes that all other weed species commonly encountered in this field were effectively controlled. The producer knows that atrazine has been used continuously on this field for 10 years and realizes that, because all other weeds that are susceptible to atrazine were controlled, this may be the early stages of the development of a triazine-resistant population of lambsquarters. With this in mind, the producer eradicates the small patch of lambsquarters by hand hoeing so that no seed will be produced by those plants. Needless to say, the producer should develop an alternative weed-management program for future years that does not rely exclusively on triazine herbicides.

Tables 2 and 3 list herbicides and herbicide premixes according to their respective sites of action. Table 2 further divides the herbicides into those that possess higher or lower potential to select for resistant weeds. The classifications are based primarily on two criteria: how extensively a particular herbicide active ingredient is (or has been) used in Illinois and scientific documentation of resistance to a particular herbicide or herbicide site of action.

Table 1. Weed species in Illinois that include herbicide-resistant biotypes and the herbicide families to which these biotypes are resistant

Weed species		
Common name	Scientific name	Resistant to herbicide family(ies)
common lambsquarters	*Chenopodium album*	triazine
smooth pigweed	*Amaranthus hybridus*	triazine, ALS inhibitors
kochia	*Kochia scoparia*	triazine, ALS inhibitors
common waterhemp	*Amaranthus rudis*	triazine, ALS inhibitors, PPO inhibitors, glyphosate
eastern black nightshade	*Solanum ptycanthum*	ALS inhibitors
giant ragweed	*Ambrosia trifida*	ALS inhibitors
common ragweed	*Ambrosia artemisiifolia*	ALS inhibitors
common cocklebur	*Xanthum strumarium*	ALS inhibitors
shattercane	*Sorghum bicolor*	ALS inhibitors
giant foxtail	*Setaria faberi*	ACCase inhibitors, ALS inhibitors
horseweed	*Conyza canadensis*	glyphosate

Table 2. Resistance potential of herbicides according to site of action

Higher potential	Lower potential
Inhibitors of acetyl-CoA carboxylase (ACCase)	**Inhibitors of microtubule assembly**
Aryloxyphenoxy propionates	*Dinitroanilines*
fenoxaprop (Puma)	benefin (Balan)
fluazifop (Fusilade DX)	pendimethalin (Prowl, Pendimax)
quizalofop (Assure II)	trifluralin (Treflan, others)
Cyclohexanediones	**Synthetic auxins—specific site unknown**
clethodim (Select, Select Max)	*Phenoxys*
sethoxydim (Poast Plus)	2,4-D (Weedone, others)
Inhibitors of acetolactate synthase (ALS)	MCPA (various)
Sulfonylureas	MCPP (various)
chlorimuron (Classic)	*Benzoic acids*
chlorsulfuron (Telar)	dicamba (Banvel, Clarity, Status)
foramsulfuron (Option)	
halosulfuron (Permit)	*Carboxylic acids*
metsulfuron (Cimarron)	clopyralid (Stinger)
nicosulfuron (Accent)	fluroxypyr (Starane)
primisulfuron (Beacon)	picloram (Tordon)
prosulfuron (Peak)	triclopyr (Garlon)
rimsulfuron (Resolve)	
sulfometuron (Oust)	**Inhibitors of Photosystem I**
thifensulfuron (Harmony GT XP)	*Bipyridiliums*
tribenuron (Express)	diquat (Reward)
	paraquat (Gramoxone Inteon)
Imidazolinones	
imazamox (Raptor)	**Inhibitors of EPSP synthase**
imazapic (Cadre, Plateau)	glyphosate (Roundup, Touchdown, others)
imazapyr (Arsenal)	
imazaquin (Scepter)	**Inhibitors of glutamine synthetase**
imazethapyr (Pursuit)	glufosinate (Liberty)
Triazolopyrimidines	**Inhibitors of lipid biosynthesis, not via ACCase**
cloransulam (FirstRate)	*Thiocarbamates*
flumetsulam (Python)	butylate (Sutan+)
	EPTC (Eradicane)
Inhibitors of photosynthesis at Photosystem II	
Triazines	**Bleaching: Inhibitors of diterpene synthesis**
ametryn (Evik)	*Isoxazolidinones*
atrazine (AAtrex, others)	clomazone (Command)
prometon (Pramitol)	
simazine (Princep)	**Bleaching: Inhibitors of 4-HPPD**
	Isoxazoles
Triazinones	isoxaflutole (Balance Pro)
hexazinone (Velpar)	mesotrione (Callisto)
metribuzin (Sencor)	topramezone (Impact)
Uracils	
bromacil (Hyvar)	
terbacil (Sinbar)	

Table 2. Resistance potential of herbicides according to site of action (cont.)

Higher potential	Lower potential
Inhibitors of photosynthesis at Photosystem II —same site, different binding behavior	**Inhibitors of photosynthesis at Photosystem II —same site, different binding behavior**
Ureas	*Nitriles*
diuron (Karmex, Direx)	bromoxynil (many)
linuron (Lorox)	
tebuthiuron (Spike)	*Benzothiadiazoles*
	bentazon (Basagran)
Inhibitors of protoporphyrinogen oxidase	
Diphenylethers	**Unknown**
acifluorfen (Ultra Blazer)	*Chloroacetamides*
fomesafen (Flexstar, Reflex)	acetochlor (Degree, Harness, TopNotch)
lactofen (Cobra, Phoenix)	alachlor (IntRRo, Micro-Tech, Partner)
	dimethenamid (Outlook)
N-phenylphthalimides	*S*-metolachlor (Dual Magnum, Dual II Magnum)
flumiclorac (Resource)	
flumioxazin (Valor)	*Oxyacetamides*
	flufenacet (Define)
Aryl triazinones	
carfentrazone (Aim)	
sulfentrazone (Spartan)	

Table 3. Premix herbicides with at least one herbicide component with a high potential for contributing to weed resistance

Photosynthetic inhibitors	ALS inhibitors
atrazine Bicep Lite II Magnum (atrazine + *S-metolachlor**) Bicep II Magnum (atrazine + *S-metolachlor)* Buctril + atrazine (atrazine + bromoxynil) Bullet (atrazine + *alachlor)* Degree Xtra (atrazine + *acetochlor)* Expert (atrazine + *S-metolachlor* + *glyphosate)* FieldMaster (atrazine + *acetochlor* + *glyphosate)* FulTime (atrazine + *acetochlor)* Guardsman Max (atrazine + *dimethenamid-P)* Harness Xtra (atrazine + *acetochlor)* Keystone (atrazine + *acetochlor)* Keystone LA (atrazine + *acetochlor)* Laddok S-12 (atrazine + *bentazon)* Lexar (atrazine + *S-metolachlor* + *mesotrione)* Lumax (atrazine + *S-metolachlor* + *mesotrione)* Marksman (atrazine + *dicamba)* Shotgun (atrazine + *2,4-D)* Steadfast ATZ (atrazine + *nicosulfuron* + *rimsulfuron)* **metribuzin** Boundary (metribuzin + *S-metolachlor)* Canopy (metribuzin + *chlorimuron)*	**imazethapyr** Extreme (imazethapyr + *glyphosate)* Lightning (imazethapyr + imazapyr) Pursuit Plus (imazethapyr + *pendimethalin)* **chlorimuron** Canopy EX (chlorimuron + tribenuron) Canopy (chlorimuron + *metribuzin)* Synchrony XP (chlorimuron + thifensulfuron) **cloransulam** Sonic, Authority First (cloransulam + *sulfentrazone)* **flumetsulam** Hornet (flumetsulam + *clopyralid)* SureStart (flumetsulam + *acetochlor* + *clopyralid)* **foramsulfuron** Equip (foramsulfuron + iodosulfuron) **thifensulfuron** Basis (thifensulfuron + rimsulfuron) Harmony Extra (thifensulfuron + tribenuron) Synchrony XP (thifensulfuron + chlorimuron) **primisulfuron** Northstar (primisulfuron + *dicamba)* Spirit (primisulfuron + prosulfuron) **rimsulfuron** Basis (rimsulfuron + thifensulfuron) Steadfast (rimsulfuron + nicosulfuron) Steadfast ATZ (rimsulfuron + nicosulfuron + *atrazine)* **nicosulfuron** Celebrity Plus (nicosulfuron + *dicamba* + *diflufenzopyr)* Steadfast (nicosulfuron + rimsulfuron) Steadfast ATZ (nicosulfuron + rimsulfuron + *atrazine)*

*Herbicides in italics have a different site of action. For example, Bicep Lite II Magnum contains a triazine component (atrazine) and a nontriazine component *(S-metolachlor)*.

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Herbicide Persistence and How to Test for Residues in Soils

Topics of Interest

- Factors affecting herbicide persistence
- Herbicide families that persist in soils
- Precautions to avoid herbicide carryover
- Testing soils for herbicide residues
- Practices to overcome herbicide residues in soils

Factors Affecting Herbicide Persistence

Herbicides are applied to the soil in hopes of obtaining season-long weed control. It is desirable for the chemicals to control weeds during the season of application, but they should not remain long enough to affect subsequent crop growth. The length of time that a herbicide remains active in the soil is called "soil persistence" or "soil residual life." Anything that affects the disappearance or breakdown of a herbicide affects persistence. Many factors determine the length of time herbicides persist. Most factors fall into three categories: soil factors, climatic conditions, and herbicidal properties. These categories strongly interact with one another.

Herbicides vary in their potential to persist in the soil. Some herbicide families that have persistent members include the triazines, uracils, phenylureas, sulfonylureas, dinitroanilines, pigment inhibitors, imidazolinones, and certain plant-growth regulators. Table 1 lists several common herbicides in these groups. Table 2 lists the soil persistence of some common herbicides.

Soil Factors

The soil factors affecting herbicide persistence fit into three categories: physical, chemical, and microbial. Soil composition is a physical factor that measures the relative amounts of sand, silt, and clay (the soil texture) and the organic-matter content of the soil. Chemical properties of the soil include pH, cation-exchange capacity (CEC), and nutrient status. The microbial aspects of the soil environment include the type and abundance of soil microorganisms present.

Soil composition affects herbicide phytotoxicity and persistence through adsorption, leaching, and volatilization. Generally, soils high in clay, organic matter, or both have a greater potential for herbicide carryover because there is increased adsorption to soil colloids, with a corresponding decrease in leaching and loss through volatilization. This "tie-up" results in decreased initial plant uptake and herbicidal activity. Therefore, more herbicide is held in reserve to be released later, potentially injuring susceptible future crops.

Some herbicides, principally the triazines (atrazine and simazine), are particularly affected by soil pH, an important part of the soil chemical makeup. Lesser amounts of these herbicides are adsorbed or held to soil colloids at higher soil pH, so they remain in the soil solution. Herbicides in the soil solution are available for plant uptake. Chemical breakdown and microbial breakdown, two major herbicide degradation processes, are often slower in soils of higher pH. So although decreased adsorption of triazine herbicides occurs in soils of higher pH, there is also less breakdown activity. Therefore, these herbicides are more available for plant uptake for a longer period on soils of higher pH. Certain members of the sulfonylurea group (chlorsulfuron

Table 1. Herbicide families with their persistent members

S-triazines
atrazine (AAtrex, Atrazine)
hexazinone (Velpar)
prometon (Pramitol)
simazine (Princep)

Dinitroanilines
benefin (Balan)
oryzalin (Surflan)
pendimethalin (Pendimax, Prowl)
prodiamine (Barricade)
trifluralin (Treflan, Tri-4, Trilin)

Others
bensulide (Betasan, Prefar)
clomazone (Command)
tebuthiuron (Spike)

Phenylureas
diuron (Karmex, Direx)

Uracils
bromacil (Hyvar-X)
terbacil (Sinbar)

Imidazolinones
imazapyr (Arsenal)
imazaquin (Scepter)
imazethapyr (Pursuit)

Sulfonylureas
chlorimuron (Classic)
chlorsulfuron (Telar)
nicosulfuron (Accent)
primisulfuron (Beacon)
prosulfuron (Peak)
sulfometuron (Oust)

Plant-growth regulators
clopyralid (Stinger)
picloram (Tordon)
triclopyr (Garlon)

and chlorimuron) can also persist in higher-pH soils because rates of chemical breakdown are decreased. Low pH affects the persistence of clomazone and the imidazolinones (imazaquin and imazethapyr). Soil pH has little effect on the persistence of other herbicides.

Research shows that various nutrients and cations in the soil affect both herbicide activity and degradation. The CEC, principally a function of clay type and organic-matter content, is directly involved in herbicide adsorption. Some herbicides are more available in the presence of certain cations, whereas others may be tied up and therefore unavailable. The literature indicates that there is much variation in the effect that cations and nutrients can have on herbicide activity and breakdown, depending on soil composition, nutrient type and concentration, and chemistry of the herbicide.

Soil microorganisms are partially responsible for the breakdown of many herbicides. The types of microorganisms and their relative amounts determine how quickly decomposition occurs. Soil microbes require certain environmental conditions for optimal growth and utilization of any pesticide. Factors that affect microbial activity are temperature, pH, oxygen, and mineral nutrient supply. Usually, a warm, well-aerated, fertile soil with a medium soil pH is most favorable for microorganisms and hence herbicide breakdown.

Climatic Conditions

The climatic variables involved in herbicide degradation are moisture, temperature, and sunlight. Herbicide degradation rates generally increase with increased temperature and soil moisture because both chemical and microbial decomposition rates increase under conditions of higher temperature and moisture. Cool, dry conditions slow degradation, causing greater carryover potential. If winter and spring conditions are wet and mild, herbicide persistence is less likely.

Sunlight is another important factor in herbicide degradation. Photodegradation, or decomposition by light, has been reported for many herbicides. The dinitroanilines (trifluralin and pendimethalin) are sensitive to light degradation. They may be lost when surface-applied if they remain for an extended time without rainfall. Therefore, degradation is accelerated on very sunny days. This sensitivity to light and loss by volatility are primary reasons for soil incorporation.

Herbicidal Properties

Finally, the chemical properties of a herbicide affect its persistence. Important factors include water solubility, soil adsorption, vapor pressure, and susceptibility to chemical and microbial alteration or degradation. The water solubility of a herbicide helps to determine its leaching potential. Leaching occurs when a herbicide is dissolved in water and moves down through the soil profile. Herbicides that readily leach may be carried away or carried to rooting zones of

Table 2. Soil persistence of some common herbicides applied at labeled Illinois use rates

1 month	1 to 3 months	3 to 12 months	More than 12 months
2,4-D	acetochlor (Degree, Harness, Surpass, TopNotch)	atrazine (AAtrex)	bromacil (Hyvar)
glufosinate (Liberty)	alachlor (IntRRo, Micro-Tech)	benefin (Balan)	chlorsulfuron (Telar)
glyphosate (Roundup, Touchdown, many)	ametryn (Evik)	bensulide (Betasan, Prefar)	imazapyr (Arsenal)
MCPA	bentazon (Basagran)	bromoxynil (Buctril, many)	picloram (Tordon)
	butylate (Sutan+)	chlorimuron (Classic)	prometon (Pramitol)
	DCPA (Dacthal)	clomazone (Command)	sulfometuron (Oust)
	dimethenamid (Outlook)	diuron (Direx, Karmex)	tebuthiuron (Spike)
	EPTC (Eptam, Eradicane)	ethalfluralin (Curbit, Sonalan)	
	flumetsulam (Python)	fomesafen (Flexstar, Reflex)	
	foramsulfuron (Option)	hexazinone (Velpar)	
	halosulfuron (Permit)	imazaquin (Scepter)	
	lactofen (Cobra, Phoenix)	imazethapyr (Pursuit)	
	linuron (Lorox)	isoxaflutole (Balance Pro)	
	mesotrione (Callisto)	oryzalin (Surflan)	
	metolachlor (Dual II Magnum)	pendimethalin (Pendimax, Prowl)	
	metribuzin (Sencor)	primisulfuron (Beacon)	
	naptalam (Alanap)	prodiamine (Barricade)	
	siduron (Tupersan)	pronamide (Kerb)	
		prosulfuron (Peak, in Spirit)	
		simazine (Princep)	
		sulfentrazone (Authority First, Sonic)	
		terbacil (Sinbar)	
		topramezone (Impact)	
		trifluralin (Treflan, many)	

susceptible plants. Herbicide leaching is determined not only by a herbicide's water solubility but also by its ability to adsorb to soil particles. Additionally, soil texture and available soil water affect herbicide leaching. Herbicides that are low in water solubility, are strongly adsorbed to soil colloids, and exist in dry soils are less likely to leach and have a greater potential to persist.

The vapor pressure of a herbicide determines its volatility, the process of changing from a liquid or a solid to a gas. Volatility increases with temperature. Volatile herbicides such as the thiocarbamates (EPTC, butylate) must be incorporated immediately to avoid gaseous losses. These herbicides are less likely to persist than herbicides with low vapor pressures.

Herbicides may be rapidly decomposed by microorganisms in the soil if the right kinds and numbers of microorganisms are present and if soil conditions are favorable for their growth. However, herbicides vary greatly in their susceptibility to microbial decomposition. For example, microbial degradation of 2,4-D occurs very quickly in the soil, whereas microbial degradation of atrazine is slow.

Chemical decomposition is dependent not only on the chemistry of the herbicide (how susceptible it is to chemical breakdown) but also on soil and climatic factors. Chemical breakdown of a herbicide involves reactions such as hydrolysis, oxidation, and reduction. The occurrence of these reactions and the rates at which they take place vary with soil type and climatic conditions. These reactions, along with microbial degradation, are important processes in the decomposition of herbicides.

Avoiding Herbicide Carryover

There are several ways to avoid herbicide carryover problems. First, always apply the correct rate of any herbicide for your specific soil type and weed problem. This means applying the lowest labeled rate of the chemical consistent with obtaining the desired effect.

To accomplish this goal, accurate acreage determination, accurate chemical measurement, proper sprayer calibration, and uniform application are essential. Always read the label before applying any herbicide.

The method and time of application can be important in avoiding herbicide carryover. Incorporation dilutes herbicides; however, herbicides that have the potential to persist longer than desired will more likely remain longer if incorporated than if surface-applied without incorporation. Incorporating the herbicide makes it less susceptible to loss by volatilization and photodegradation. In addition, an incorporated herbicide is immediately exposed to soil particles and may be tied up temporarily through adsorption and later released. Decreased environmental losses (volatilization and photodegradation) and increased adsorption favor herbicide carryover. Banded herbicide applications can reduce carryover potential because less total herbicide is applied than in a broadcast application. Postemergence and late soil applications have greater potential than earlier applications for being present the following season.

The amount of tillage affects herbicide persistence. Tillage encourages herbicide decomposition indirectly through increased microbial and chemical breakdown. Minimum-till and no-till, which leave crop residue on the soil surface, also tend to leave a greater concentration of herbicide near the surface zone. Persistent herbicides present in this concentrated zone may affect susceptible crops. In addition, higher rates of herbicides are often used in reduced-tillage systems to maximize weed control and adjust for greater amounts of crop residues. If a herbicide-carryover problem already exists, some tillage to dilute the chemical may help.

Herbicide combinations may reduce the risk of carryover problems. By tank-mixing two or more herbicides, you may reduce the application rates of those products that can potentially cause problems and at the same time broaden the weed-control spectrum.

Herbicides may interact with one another or with other pesticides and may enhance crop injury when applied in the same year or in consecutive years. For example, a soybean crop may tolerate a certain level of atrazine carryover. However, if another photosynthetic inhibitor, such as metribuzin, is applied to soybeans after atrazine-treated corn, injury is more likely.

Plants absorb herbicides from the soil in which they are growing. Persistence may be reduced if the herbicide is metabolized (broken down) by the plant or if the plant containing the absorbed herbicide is harvested and removed from the field. Plant extraction of the herbicide from the soil may not be an important factor under most situations, but it has been used in some cases to help remove persistent herbicides from treated soils.

Finally, the selection of a tolerant rotational crop or variety helps minimize carryover problems. Quite often, economics dictates crop rotation; however, there are varietal differences that might affect the likelihood of serious crop injury. For example, some soybean varieties are more sensitive to the triazine herbicides than others and should not be used if the potential for triazine injury exists. Also, as a general rule, smaller-seeded crops and varieties have a greater potential for injury from persistent herbicides than do larger-seeded species.

Many variables interact in predicting herbicide persistence. Factors involved in the degradation of herbicides include many soil, climatic, and herbicidal properties. The potential for herbicide carryover problems can be reduced by using the appropriate rates and accurate timing of proper application methods. The use of selective tillage, herbicide combinations, and tolerant crops and varieties can also help reduce the risk of crop injury.

Testing for Herbicide Residues

If herbicide carryover is suspected, a soil chemical test or a bioassay can be used to determine if harmful levels of herbicide are present. Chemical analysis can be expensive, so a bioassay conducted either in the suspect field or in a warm, sunny indoor location (such as a greenhouse) may be more feasible. These tests help predict potential herbicide-residue problems so the grower can make better decisions about crop rotation, herbicide selection, planting date, and other cultural practices.

Soil Collection and Preparation

With the lab analysis or indoor bioassay, proper sampling of soil is the first step. The procedures for submitting a soil for laboratory analysis and for conducting an indoor bioassay are similar. These guidelines should be followed:

1. In early spring to midspring or before planting time, collect representative soil samples from the suspect field. Take samples from several locations in the field. For the bioassay or laboratory analysis, take 15 to 20 soil cores and combine them to make a composite sample. This sample should represent no more than 15 to 20 acres. Enough areas must be sampled to avoid missing locations with high herbicide-residue content. Take separate samples from areas where excessive residues are suspected,

such as sprayer turnaround points and end rows. Do not mix these samples with the others. Sample the soil to a 6-inch depth, and divide the samples into two sections for greater accuracy—those from 0 to 3 inches and those from 3 to 6 inches. Be sure to mark on the bags the depths from which the samples came. About 8 pounds of soil (about 4 quarts) are needed for each bioassay and 2 pounds of soil (about 1 quart) for each laboratory analysis.

2. Sample an area that is not suspect for use as a "check" soil. This soil may be taken from a nearby fencerow or another untreated area. Keep this sample separate from the others. Many laboratories require a check soil.
3. Submit the samples to the laboratory as soon as possible after sampling. If bioassays are to be performed, they should be run on the soil samples as soon as possible after they have been obtained from the field. If samples cannot be assayed immediately, store the soil in a refrigerator or freezer that is not used for food. If samples are stored in a warm environment, herbicide residue may decrease with time.

Bioassay

The bioassay can help predict potential crop injury. The test is inexpensive and can be done with a few simple supplies. A bioassay does not measure the amount of herbicide residue present in the soil, but it may indicate whether or not enough residue is present to injure a sensitive crop.

Field Bioassay

A field bioassay is conducted by planting one or more strips of a species sensitive to the suspect herbicide in the field. This procedure can be done in the fall or spring, but it is more accurate when performed closer to the planting of the intended crop. Before planting the desired crop, allow the test plants to grow and develop symptoms of injury from any herbicide residues. Plant the strips in several locations, if possible, and include an area that is most suspect and an area that can serve as a check. Choose an appropriate species for the bioassay, such as one of the more sensitive ones listed in this chapter. Include several species of differing sensitivity for greater accuracy.

Indoor Bioassay

The procedures for conducting an indoor bioassay vary, depending on what herbicide residue is of concern. However, for the indoor bioassay, the procedures for soil collection and preparation are the same.

1. For an indoor bioassay, collect the samples and allow them to air dry if needed until they can be worked readily. Do not overdry. If the soil is cloddy, crush the clods into pieces (the size of a pea or smaller). If the soil contains a high amount of clay, the addition of coarse sand (50 percent by volume) improves its physical condition. If sand is added, mix it thoroughly with the soil.
2. Tin cans, milk cartons, and cottage cheese containers are appropriate containers in which a bioassay can be conducted. Punch holes in the bottoms of the containers to allow water drainage. Fill two or more containers (a set) with soil from each sample. Additional containers increase the accuracy of the test. Place the soil samples obtained from depths of 0 to 3 inches in one set of containers; in another set, place the soil obtained from depths of 3 to 6 inches. Follow this procedure for the composite sample and the sample taken from areas where excessive residues are expected. In addition, fill a final set of containers with the check soil.

Testing for Specific Herbicide Groups

Triazine Residues

For suspected carryover from triazine herbicides, such as atrazine and Princep (simazine), an oat plant bioassay works best. Place about 15 oat seeds in each container of soil and cover the seeds with about 1 inch of soil. Wet the soil with water, but do not saturate it.

Place the containers in a warm location (70° to 75°F) where they can receive ample light. Sunlight is essential for the development of the plant, as well as for inducing symptoms of triazine injury. The container should be watered as needed.

Injury symptoms should become apparent within 10 to 14 days after emergence. Triazine injury is characterized by chlorosis (yellowing), then necrosis (browning) of leaf tissue. As injury symptoms start at the leaf tip and develop toward the base, a comparison with the plants in the check soil is essential.

If injury appears on the oats, enough herbicide residue may be present to injure a susceptible crop. Planting a more tolerant crop is suggested. In general, the order of susceptibility from most to least susceptible to triazine herbicides is as follows:

Ryegrass > Alfalfa > Oats > Wheat > Soybean > Sorghum > Corn

DNA Residues

If residues from dinitroaniline (DNA) herbicides, such as Treflan (trifluralin) or Prowl, Pendimax (pendime-

thalin), are suspected, a different assay technique is used. A sorghum or corn root bioassay is relatively quick and easy to perform.

Wrap a number of sorghum or corn seeds in a moist paper towel and store them at room temperature for 2 to 3 days. This procedure allows the seed to imbibe water and germinate. Once the seed has germinated, carefully place three to five seeds into containers with the suspect soil and the check soil. Cover the seeds with soil to a depth of about 1 inch and leave them for 10 to 14 days, depending on the air temperature. Water the plants as needed but do not saturate the soil.

At the end of the period of 10 to 14 days, carefully remove the plants and observe the root formation. DNA herbicides inhibit root development. Symptoms include stunted plants, stubbed roots, inhibited root-hair development, thickened hypocotyls on broadleaf species, and leaves that fail to unroll. If the plants in the suspect soil display any of these symptoms in comparison to the check plants, DNA residues may be present at concentrations high enough to injure susceptible crops. In general, the order of susceptibility from most to least susceptible to DNA herbicides is as follows:

Annual rye > Oats > Sorghum > Corn > Wheat > Alfalfa > Soybean

Imazaquin, Imazethapyr, and Chlorimuron Residues

Imazaquin, the active ingredient in Scepter; imazethapyr, the active ingredient in Pursuit and a component of Pursuit Plus, Extreme, and Lightning; and chlorimuron, the active ingredient in Classic and a component of Canopy, Canopy EX, and Synchrony XP, have the same mode of action. These herbicides affect root and shoot growth and development. Symptoms of plant injury include inhibited root development, stunted plants, and interveinal chlorosis or leaf striping. Therefore, a sorghum or corn-root bioassay performed according to the procedure outlined for suspected DNA residue is appropriate. Corn is more sensitive to imazaquin, and sorghum is more sensitive to imazethapyr and chlorimuron. In addition to making root observations, look for stunted shoot growth and interveinal chlorosis or yellowing. Bioassay plants should be grown for 14 to 21 days. The order of crop susceptibility from most to least susceptible to imazaquin, imazethapyr, and chlorimuron is as follows:

Imazaquin: Canola > Alfalfa = Corn = Sunflower > Sorghum > Oats > Wheat > Soybean

Imazethapyr: Canola > Sorghum > Sunflower > Oats > Wheat > Corn > Alfalfa > Soybean

Chlorimuron: Canola > Alfalfa > Sunflower > Sorghum > Corn > Oats > Wheat > Soybean

Introduction and commercialization of Clearfield (CL) corn hybrids resistant to the imidazolinone herbicides provide producers with a viable option for corn production in fields suspected of having soil-residue levels (carryover) of imidazolinone herbicides high enough to cause injury to conventional hybrids. If bioassay results show residue levels of imidazolinone herbicides are high enough to cause potential injury to conventional hybrids, you may consider planting a Clearfield hybrid if corn is the rotational crop of choice.

Command (Clomazone) Residues

Clomazone, the active ingredient in Command, inhibits the production of photosynthetic pigments in susceptible plants, causing them to emerge lacking green color (that is, they are white). Lower levels of Command injury may appear as a chlorosis or mild bleaching of the plants. Oats or wheat can be used to detect Command residues using the same procedure as was outlined for detecting triazine residues. Bioassay plants should be grown for 10 days to 2 weeks. Susceptible plants that are exposed to significant levels of Command residues will be white, while untreated or tolerant plants will be green. Keep in mind that oats and wheat are usually more susceptible than corn to injury from Command. The order of susceptibility from most to least susceptible to Command residues is as follows:

Oats = Wheat = Alfalfa > Sunflower = Sorghum = Corn > Soybean

Other Residues

Bioassays may be made for other herbicides using similar techniques. If the site of action of a specific herbicide is known, then a procedure for detecting the herbicide can be developed. For example, if the herbicide is a root meristematic inhibitor (that is, if it stops cell division in the roots), then a root bioassay is the appropriate test. If the herbicide inhibits photosynthesis, then injury symptoms first appear in the leaves. Choose a species that is moderately susceptible to the suspected herbicide, and always include a check soil. Wheat and oats are very good indicator plants for many herbicides but may be more sensitive than the desired crop. Include several species in the bioassay to give a better range of susceptibility. The desired rotational crop is a good bioassay plant to include.

Laboratory Analysis

Laboratory analysis involves extracting herbicide from the soil with the use of specialized equipment to detect very small amounts. The amount is usually expressed in parts of herbicide per million parts of soil (ppm). This measurement can be transposed into pounds of herbicide active ingredient per acre (lb a.i./A) if we assume that an acre of soil weighs 1 million pounds in the top 3 inches and 2 million pounds in the top 6 inches. For a soil sample taken to a 3-inch depth, 1 ppm = 1 lb/A of residue. For a soil sample taken to a 6-inch depth, 1 ppm = 2 lb/A of residue.

A lab report of 0.2 ppm atrazine, then, means that there is 0.2 pound of atrazine per acre if the samples were taken to a 3-inch depth, and 0.4 pound per acre if taken to a 6-inch depth.

The location and concentration of the chemical depend on the herbicide used, the soil type, whether the ground was tilled, and the amount of rainfall since application. In most medium-textured soils (silt loams, silty clay loams, sandy clay loams), the herbicide remains primarily in the top 3 inches unless there was excessive rainfall, the ground was plowed, or the herbicide was deeply incorporated. If the soil has a high sand content (coarse texture), then herbicide leaching may be greater. Movement of the herbicide from the surface soil zone by tillage or by rainfall decreases the likelihood of crop injury. The risk of injury is greater when the herbicide residue is concentrated in the top 3 inches rather than distributed throughout a 6-inch soil depth. Therefore, it is best to sample in two separate sections, from 0 to 3 inches and from 3 to 6 inches.

Whether parts per million or pounds of active ingredient of herbicide per acre is used, it is difficult to translate these units of measure into potential crop injury. Many variables affect crop susceptibility or tolerance, including soil type, crop sensitivity, and environmental conditions after planting. Crop injury is more likely on more coarsely textured soils or under cool, wet weather conditions. Additionally, high soil pH increases the potential of triazine or chlorimuron injury. General guidelines are provided in Table 3, although you are cautioned that crop injury may still occur below these levels.

Laboratories may differ in available tests and in the prices for analysis. The cost can range from $20 to $200 per sample for herbicide analysis. Most laboratories can analyze a sample and have the results in 5 to 7 days. Contact your local Extension office for more information on laboratory selection.

Correcting for Herbicide Residues

If the lab test or bioassay indicates a potential herbicide-residue problem, several steps can be taken.

1. First select a tolerant crop or variety. This selection depends on what herbicide is of concern. Check current herbicide labels for more information on crop tolerance.
2. Tillage can help dilute herbicide in a problem field.
3. Plant the field that concerns you last. Delaying planting allows more time for the herbicide to dissipate.
4. If the triazine herbicides or chlorimuron is suspect, be sure to check the soil pH and adjust your management practices accordingly.
5. If imazaquin or imazethapyr is suspect, check for low soil pH (< 5.5). Liming would both benefit crop growth and minimize carryover of these herbicides.

Soil bioassays or laboratory tests are not 100 percent accurate in predicting herbicide-residue problems. Crop response to herbicide residue depends on various factors, including species and variety, soil type, and environmental conditions after planting. So, predicting crop injury is often difficult. However, using a soil chemical test or bioassay can help in deciding whether a potential problem exists and in choosing the appropriate crop or variety.

Table 3. General guidelines for interpreting laboratory soil analysis

Herbicide	Safe level*		Crop
	Parts per billion	Parts per million	
Triazine	150–250	0.150–0.250	Soybean
	40–100	0.04–0.100	Alfalfa
	60–150	0.06–0.150	Oats
	75–180	0.075–0.180	Wheat
Dinitroaniline	100–200	0.100–0.200	Corn
	200–300	0.200–0.300	Wheat
Clomazone	50–200	0.050–0.200	Corn
	15–100	0.015–0.100	Wheat, alfalfa
Imazaquin	2–10	0.002–0.010	Corn
	10–30	0.010–0.030	Wheat
Imazethapyr	10–30	0.010–0.030	Corn
	4–15	0.004–0.015	Sorghum
Chlorimuron	1–2	0.001–0.002	Corn
	2–5	0.002–0.005	Wheat

*Due to differences in herbicide availability from the soil, "safe" values for herbicide residues differ according to soil type. Low-range values are for coarsely textured soils with low levels of organic matter; higher-range values are for finely textured soils with higher levels of organic matter. 1 ppm = 1,000 ppb.

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Pesticide Licensing Requirements and Restricted Use Pesticide List

This chapter is intended to provide clear information about the pesticide licensing requirements in Illinois. It also includes a comprehensive list of restricted use pesticides (RUPs) and information about the associated record-keeping requirements. For more information about pesticide safety and the other pesticide, worker, and environmental laws in Illinois, contact your local University of Illinois Extension office. Extension's publication *Pesticide Applicator Training Manual: General Standards* is a valuable resource that addresses pesticide laws and safety issues in detail.

Illinois Pesticide Act Licensing Requirements

A pesticide license is required of everyone who purchases or applies RUPs. The words "Restricted Use Pesticide" are prominently displayed on every RUP label. Also, anyone applying any restricted or general use pesticides in the course of employment must have a license. However, a person using a general use pesticide on his or her own or rented property is exempt.

The Illinois Department of Agriculture certifies and licenses those individuals who use pesticides in outdoor environments and in the production of agricultural commodities. University of Illinois Extension provides training and study materials for those seeking licenses. This chapter provides licensing information for these uses.

The Illinois Department of Public Health certifies and licenses individuals using pesticides in and on manufactured structures. Such uses include nuisance bird control, rodent control, wood treatment, and insect control. This chapter does not cover licensing for structural pest control.

Types of Licenses

Private Applicator License. This license is required for people applying restricted use pesticides to produce an agricultural commodity on property they own or control. In addition, private applicators must pass the Grain Fumigation certification exam in order to fumigate their own grain bins. For information concerning private applicator and grain fumigation training and testing, contact your local University of Illinois Extension office. The current fee is $20 for a 3-year license, with or without Grain Fumigation certification.

Pesticide Dealer License. An individual selling restricted use pesticides must be licensed. Also, an individual selling nonrestricted use (general use) pesticides for the production of an agricultural commodity in containers with capacities equal to or greater than 2½ gallons or 10 pounds must be licensed. A test, license, and fee are required for certification. Also, pesticide dealers are required to keep records of RUP sales for 2 years. Commercial Applicators and Structural Pest Control Operators are exempt from the test and fee, but they must register as dealers. The current fee is $100 for a 1-year license; however, the certification exam is valid for a period of 3 years if no lapse in licensure occurs.

Commercial Applicator and Operator Licenses. These licenses are required for individuals who use or supervise the use of general or restricted use pesticides for hire. The current fee is $60 for a 1-year applicator's license or $40 for a 1-year operator's license; however, the certification exam is valid for a period of 3 years if no lapse in licensure occurs.

Public Applicator and Operator Licenses. These licenses are required for individuals who use or

The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.

Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.

supervise the use of pesticides classified for general or restricted use as an employee of a state agency, municipality, or other duly constituted governmental agency or unit. There is no license fee, and the certification exam is valid for a period of 3 years if no lapse in licensure occurs.

Commercial Not-for-Hire Applicator and Operator Licenses. These licenses are required for individuals who use or supervise the use of pesticides classified for general or restricted use for any purpose on property of an employer when such activity is a requirement of the terms of employment and the application is limited to property under the employer's sole control. There is no license fee, and the certification exam is valid for a period of 3 years if no lapse in licensure occurs.

Applicator vs. Operator License

Applicators. An applicator (Commercial, Public, or Commercial Not-for-Hire) is the person in an organization who has the responsibility for all pesticide purchasing, storage, handling, and use. Each organization must have at least one person licensed as an applicator at each facility location. The categories included on the applicator's license dictate the areas where a company may legally apply pesticides. An applicator is usually an owner, a supervisor, or a foreman. An applicator may use pesticides or supervise the use of pesticides by licensed operators.

The following are requirements for obtaining an applicator license:

- *Pass a General Standards exam.* An applicant must pass either the General Standards or the Aerial General Standards exam; each exam has 100 questions.
- *Pass one or more category exams.* The category exams are 50-question tests on specialized topics. Category selection depends on the sites where the company uses pesticides.
- *Complete the license application.* After you pass your exam(s), an application will be sent to you. Submit the completed application to the Illinois Department of Agriculture within 90 days. If 90 days elapse, you must retest.
- *Provide a certificate of insurance.* In addition to paying the license fee, commercial applicators must provide a certificate of insurance with proper coverage. The insurance requirements will be sent to you along with your application.

Operators. An operator (Commercial, Public, or Commercial Not-for-Hire) is a person who uses pesticides at the job site. The operator's license is tied directly to a specific applicator's license. An individual cannot be licensed as an operator unless he or she works with a properly licensed applicator. Furthermore, an operator may not legally apply pesticides for any other applicator. The operator can apply pesticides only under the direct supervision of the applicator and can apply pesticides only to areas covered by the applicator's license. Supervision and direction of operators by an applicator is interpreted to mean that the applicator must be in daily contact with the operators. If the applicator is out of town or not available, the operator may not legally apply pesticides.

The following are requirements for obtaining an operator's license:

- *Provide proof of employment by a licensed applicator.* Operators must be employed and supervised by a currently licensed applicator.
- *Pass a General Standards exam.* An applicant must pass either the General Standards exam or the Aerial General Standards exam; each exam has 100 questions.
- *Complete the license application.* After you pass your exam, an application will be sent to you. Submit the application to the Illinois Department of Agriculture within 90 days. If 90 days elapse, you must retest.

Technical Categories of Licensure

Each technical category is designed to cover pesticide use requiring specific professional knowledge. An applicator's license must include all categories necessary to cover a company's entire range of pesticide use. Many applicators need multiple categories on licenses.

- *Aquatic pest control.* Pesticide use for weed control in standing or running water.
- *Demonstration and Research.* Pesticide use during research or during the teaching of proper pesticide and equipment use.
- *Field Crop pest control.* Pesticide use in corn, soybeans, small grains, forages, grasslands, etc.
- *Forest pest control.* Pesticide use in forests, forest nurseries, and forest seed-producing areas.
- *Fruit Crop pest control.* Pesticide use in fruit and nut crops.
- *Grain Facility pest control.* Noncommercial pesticide use in and around grain elevators or similar grain-holding facilities, conveyances, and transportation facilities.
- *Grain Fumigation pest control.* Pesticide use by private applicators to treat stored grain on their own property.
- *Livestock pest control.* Pesticides applied to livestock or livestock barns.
- *Mosquito control.* Insecticides applied to control mosquitoes.
- *Ornamental pest control.* Pesticide use on trees, shrubs, and ornamental plantings.

- *Plant Management pest control.* Pesticide use on portable plants used for interior landscaping and environmental enhancement.
- *Regulatory pest control.* Pesticide use by government employees involved in the control of regulated pests.
- *Rights-of-Way pest control.* Chemical weed control on noncrop sites, such as on parking lots, along roads, in access rights-of-way, and in fence lines.
- *Sewer Line Root control.* Chemical control of roots in sewer lines.
- *Seed Treatment.* Pesticide use on seeds.
- *Soil Fumigation.* Pesticide use for soil fumigation.
- *Turf pest control.* Pesticide use on turf areas and sod farms.
- *Vegetable Crop pest control.* Pesticide use in vegetable crops.

Important Addresses and Phone Numbers

Commercial Clinic Preregistration and Study Material Information. The University of Illinois Extension Pesticide Applicator Training (PAT) Program is responsible for pesticide training as well as answering questions regarding training availability, schedules, clinic preregistration, and study materials. For information, contact

University of Illinois
Pesticide Safety Education Program
1201 S. Dorner Dr.
Urbana, IL 61801
Phone: (800)644-2123 or (217)244-2123
Fax: (217)244-3469

License Information. The Illinois Department of Agriculture is responsible for pesticide testing and licensing, and agency representatives can answer questions regarding required exams, category requirements, and license availability. For information, contact

IDA/Bureau of Environmental Programs
P.O. Box 19281
State Fairgrounds
Springfield, IL 62794-9281
(217)785-2427(TDD)
(800)641-3934

or

IDA/Bureau of Environmental Programs
2280 Bethany Rd., Suite B
DeKalb, IL 60115
(815)787-5476

Structural Pest Control. The Illinois Department of Public Health is responsible for training and testing in category 7 (indoor, structural pest control). For information about this category of licensure, contact

IDPH/Division of Environmental Health
525 W. Jefferson, 3rd Floor
Springfield, IL 62761
(217)782-4674

Restricted Use Pesticides

In 1972, amendments to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) provided the legal mechanism for restricting the use of certain pesticides. The U.S. Environmental Protection Agency (USEPA), confronted with the enormous task of reviewing all registered pesticides, proposed to classify pesticides by their active ingredients, subdividing each active ingredient into its various formulations or uses. This classification system provided the USEPA with more flexibility to restrict some, but not all, products containing the same active ingredient. The process was called classification by regulation. When pesticides are restricted in this manner, the manufacturer is given 270 days to amend the label on all the affected products. This timetable has been of particular interest to pesticide dealers because once the restricted use label is applied to the container, it can be sold only to a certified applicator.

In addition to reviewing existing products, the USEPA is required to register products not previously marketed. Some of these new products have been classified for restricted use. This process is called classification by registration.

Pesticides classified for restricted use by registration and regulation are listed in Table 1. This list is based on Illinois Department of Agriculture (IDA) lists dated September 2007. Some active ingredients are restricted use only in higher concentrations and some formulations. Refer to the IDA Web site listed at the end of this chapter for details and updates.

Record-Keeping Requirements

All certified applicators are required to keep records of applications of federally restricted use pesticides (RUPs). These records are required under the Food, Agriculture, Conservation, and Trade Act of 1990, also known as the 1990 Farm Bill. Record keeping has been required of commercial applicators in Illinois since 1988 under the Illinois Pesticide Act. There is no required form for either regulation. Any form is acceptable as long as the required information are included.

Private Applicators

The federal regulations require all certified private applicators (those who apply pesticides to their own land) to maintain records of RUP applications. Records must be recorded within 14 days of the RUP application and maintained for 2 years. Federal regulations require that records for RUP applications must include the following information:

- brand or product name and the EPA registration number
- total amount applied
- location of the application
- size of the area treated
- crop, commodity, stored product, or site to which a RUP was applied
- month, day, and year of the application
- name and certification number of the certified applicator who applied or who supervised the application of the RUP

Spot applications, where a RUP is applied to an area less than one-tenth of an acre, require less stringent records. Only the product name and registration number, amount applied, location, and date must be recorded. Greenhouses and nurseries are excluded from using spot applications in their records.

Commercial Applicators

All commercial applicators must continue to maintain the records they currently keep under Illinois regulations. In addition, the federal regulations require all commercial applicators to furnish a copy of either the state or federally required records to the customer within 30 days of the RUP application. Records must be maintained for 2 years from the date of application.

Requirements for records of RUP applications under the Illinois Pesticide Act include the following:

- brand or product name and the EPA registration number
- amount applied
- use site
- month, day, and year of the application

For more information, contact the Illinois Department of Agriculture at (217)785-2427 or your local Extension office.

Table 1. Restricted use pesticides

Active ingredient	Trade name	Type	Criteria for restricted use
abamectin	Agri-Mek, Zephyr	Insecticide	Toxic to mammals and aquatic organisms
acetochlor	Degree, Harness, Surpass, TopNotch	Herbicide	—[a]
acrolein	Magnacide B	Herbicide	Human inhalation hazard; avian and aquatic toxicity
alachlor	many	Herbicide	Oncogenicity
aldicarb	Temik	Insecticide–nematicide	Accident history
aluminum phosphide	Detia, Phostoxin, many others	Fumigant	Human inhalation hazard
arsenic acid	CCA	Herbicide, wood preservative	Fetotoxicity; mutagenicity; oncogenicity; reproductive effects
arsenic pentoxide	many	Wood preservative	Oncogenicity; mutagenicity; reproductive and fetotoxic effects
atrazine	many	Herbicide	Groundwater contamination; worker exposure

Table 1. Restricted use pesticides (cont.)

Active ingredient	Trade name	Type	Criteria for restricted use
avitrol	Avitrol	Avicide	Hazard to fish and nontarget birds
azinphosmethyl	Guthion	Insecticide	Acute toxicity
bifenthrin	Brigade, Capture, Talstar	Insecticide	Toxicity to aquatic organisms
carbofuran	Furadan	Insecticide–nematicide	Acute inhalation toxicity; bird toxicity
chlorethoxyfos	Fortress	Insecticide	Human, bird, and aquatic invertebrate toxicity
chlorophacinone	Rozol Tracking Powder	Rodenticide	Human hazard; potential for food contamination
chloropicrin	many	Fumigant	Acute inhalation toxicity; hazard to nontarget organisms
chlorpyrifos	Cyren, Dursban, Lorsban, others	Insecticide	Avian and aquatic toxicity
chromic acid	CCA (Chromated Copper Arsenate), others	Wood preservative	Oncogenicity; mutagenicity; teratogenicity; fetotoxic effects
coumaphos	CO-RAL	Insecticide	Acute oral toxicity
creosote oil, coal tar creosote, coal tar	many	Wood preservative	Possible oncogenicity and mutagenicity
cuprous oxide	Hempel's Combic, Osmos ACC	Fungicide	—[a]
cyfluthrin	Aztec, Baythroid, Tempo	Insecticide	Toxicity to applicator; toxicity to fish and other aquatic organisms
cypermethrin	Ammo, others	Insecticide	Hazard to nontarget organisms; oncogenicity
deltamethrin	Decis, Deltagard	Insecticide	Toxicity to aquatic organisms
diazinon	Diazinon	Insecticide	Avian and aquatic toxicity
dichlobenil	Sanafoam, Vaperooter II, Sewerout	Herbicide	Conditional
dichloropropene	Telone, others	Fumigant	Possible oncogenicity; acute toxicity
diclofop methyl	Hoelon	Herbicide	Oncogenicity
dicrotophos	Mauget Inject-A-Cide B	Insecticide	Acute dermal toxicity; residue effects on birds

Table 1. Restricted use pesticides (cont.)

Active ingredient	Trade name	Type	Criteria for restricted use
diflubenzuron	Dimilin	Insecticide	Hazard to wildlife
diphacinone	Ditrac	Rodenticide	Acute oral toxicity
disulfoton	Di-Syston	Insecticide	Acute dermal and inhalation toxicity
emamectin benzoate	Proclaim	Insecticide–miticide	Fish toxicity
EPTC	Eptam, Eradicure	Herbicide	—
esfenvalerate	Asana, others	Insecticide	Possible adverse effects on aquatic organisms
ethoprop	Mocap	Insecticide	Acute dermal toxicity
fenamiphos	Nemacur	Nematicide	Acute toxicity; bird toxicity
fenbutatin-oxide	Vendex	Miticide	Toxicity to aquatic organisms
fenpropathrin	Danitol, Tame	Insecticide	Toxicity to aquatic organisms
fipronil	Regent	Insecticide–miticide	Conditional
gamma-cyhalothrin	Proaxis, Prolex	Insecticide	Toxicity to aquatic organisms
imidacloprid	Leverage	Insecticide	Toxicity to aquatic organisms
isoxaflutole	Balance	Herbicide	Phytotoxicity
lambda-cyhalothrin	Karate, Mustang, Scimitar, Warrior	Insecticide	Toxicity to fish and aquatic invertebrates
magnesium phosphide	Fumi-Cel	Fumigant	Inhalation hazard
methamidophos	Monitor	Insecticide	Acute dermal toxicity; avian residue effects
methiocarb	Mesurol	Molluscicide	Possible hazard to birds and aquatic organisms
methomyl	Lannate	Insecticide	Residue effects on mammals; accident history
methyl bromide	many	Fumigant	Accident history; acute toxicity
methyl isothiocyanate	MITC-Fume	Wood preservative	Exceeds classification criteria
methyl parathion	Penncap-M	Insecticide	Acute dermal toxicity; hazard to wildlife
S-metolachlor	Lexar	Herbicide	—

Table 1. Restricted use pesticides (cont.)

Active ingredient	Trade name	Type	Criteria for restricted use
milbemectin	Ultiflora	Insecticide	—
nicotine	Nicotine	Insecticide	Acute inhalation toxicity; effects on aquatic organisms
nicarbazin	Ovocontrol	Avicide	—
oxamyl	Vydate	Insecticide, nematicide	Acute oral and inhalation toxicity; bird toxicity
oxydemeton-methyl	Metasystox R	Insecticide	Reproductive effects
paraquat	Cyclone, Gramoxone	Herbicide	Use and accident history; human toxicity
permethrin	Pounce, others	Insecticide	Toxicity to aquatic organisms; oncogenicity
phorate	Phorate, Thimet	Insecticide	Acute toxicity; effects on birds, mammals, and aquatic organisms
phosphine gas	EcoFume, Vaporphos	Fumigant	Acute inhalation toxicity
picloram	Grazon, Tordon	Herbicide	Hazard to nontarget organisms
profenofos	Curacron	Insecticide, acaricide	Corrosive to eyes
pronamide	Kerb	Herbicide	—
resmethrin	many	Insecticide	Fish toxicity
rotenone	Prenfish	Fish control	Chronic eye and inhalation effects
starlicide	Gull-Toxicant	Bird repellent	Hazard to nontarget organisms
strychnine	many	Rodenticide	Acute oral toxicity; effects on nontarget organisms; accident history
sulfuryl fluoride	Vikane	Fumigant	Acute inhalation hazard; acute human toxicity
tefluthrin	Force	Insecticide	Toxicity to aquatic organisms
terbufos	Counter	Insecticide	Acute toxicity; bird toxicity
thiodicarb	Larvin	Insecticide	Hazard to nontarget organisms
triphenyltin hydroxide	SuperTin	Fungicide	Possible mutagenic effects
zinc phosphide	many	Rodenticide	Acute oral and inhalation toxicity; hazard to nontarget organisms

[a]Information not available.

Recommended Web Resources

http://www.kellysolutions.com/IL/searchbyRup.asp
The Illinois Department of Agriculture's pesticide registration Web site.

http://www.pesticidesafety.uiuc.edu
The University of Illinois's pesticide safety education Web site. This resource includes information on Worker Protection Standards.

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Conversions

Fluid

⅙ fluid ounce (oz) = 1 teaspoon (tsp)
½ fluid ounce = 1 tablespoon (tbs) = 3 teaspoons
1 fluid ounce = 2 tablespoons = ⅛ cup = 29.57 milliliters
8 fluid ounces = 1 cup = ½ pint (pt)
16 fluid ounces = 2 cups = 1 pint
32 fluid ounces = 4 cups = 1 quart (qt) = 946 milliliters
128 fluid ounces = 16 cups = 1 gallon (gal.)

Linear

1 inch = 2½ centimeters (cm) = 25½ millimeters
1 foot = 12 inches (in.)
1 yard (yd) = 3 feet (ft)
1 rod = 5½ yards = 16½ feet
1 mile = 320 rods = 1,760 yards = 5,280 feet

Weight

1 ounce = 28⅓ grams (g)
1 pound (lb) = 16 ounces = 453½ grams
2⅕ pounds = 1 kilogram = 1,000 grams
1 ton = 2,000 pounds = 907 kilograms

Area

144 square inches = 1 square foot
9 square feet = 1 square yard
30¼ square yards = 1 square rod = 272¼ square feet
43,560 square feet = 1 acre
4,840 square yards = 1 acre
160 square rods = 1 acre
640 acres = 1 square mile

Dilution Tables

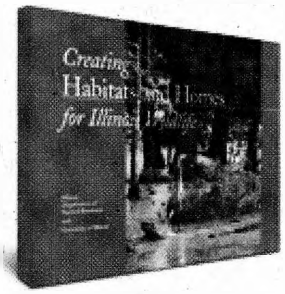
Amount of Liquid Pesticide Product Required to Obtain Recommended Rate

	Recommended pesticide active ingredient (a.i.) per acre or 100 gallons of water				
	1/4 pound	1/2 pound	1 pound	2 pounds	3 pounds
Concentration of liquid formula	Amount of Pesticide Required				
1 pound/gallon	1 quart	2 quarts	1 gallon	2 gallons	3 gallons
1½ pounds/gallon	1⅓ pints	1⅓ quarts	5⅓ pints	5⅓ quarts	2 gallons
2 pounds/gallon	1 pint	1 quart	2 quarts	1 gallon	6 quarts
4 pounds/gallon	8 ounces	1 pint	1 quart	2 quarts	3 quarts
6 pounds/gallon	6 ounces	10 ounces	1⅓ pints	1⅓ quarts	2 quarts
8 pounds/gallon	4 ounces	8 ounces	1 pint	1 quart	3 pints

Amount of Dry Pesticide Product Required to Obtain Recommended Rate

	Recommended pesticide active ingredient (a.i.) per acre or 100 gallons of water				
	1/4 pound	1/2 pound	1 pound	2 pounds	3 pounds
Concentration of dry formula	Amount of Pesticide Required				
15%	1⅔ pounds	3⅓ pounds	6½ pounds	13 pounds	20 pounds
25%	1 pound	2 pounds	4 pound	8 pounds	12 pounds
40%	10 ounces	1¼ pounds	2½ pounds	5 pounds	7½ pounds
50%	8 ounces	1 pound	2 pounds	4 pounds	6 pounds
65%	6 ounces	12 ounces	1½ pounds	3 pounds	4½ pounds
75%	5⅓ ounces	11 ounces	1⅓ pounds	2⅔ pounds	4 pounds
80%	5 ounces	10 ounces	1¼ pounds	2½ pounds	3¾ pounds

Other publications from University of Illinois Extension

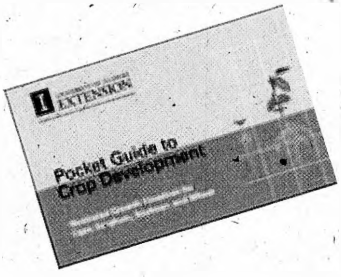


Creating Habitats and Homes for Illinois Wildlife

This beautiful book will inspire and encourage you to enjoy and conserve the rich wildlife legacy of the Midwest. Chock-full of stunning color photos and concise, practical information, *Creating Habitats and Homes for Illinois Wildlife* will give you the know-how and confidence to create an environment that attracts wildlife to your land or even to your backyard. *DNR01. $25.00.*

Field Crop Scouting Manual (5th ed.) book and CD set

This comprehensive manual helps you identify and evaluate common problems in the field. It describes nutrient deficiencies, herbicide injuries, insects, diseases, weeds, and other agronomic crop problems. Filled with color photos, line drawings, and scouting worksheets and guidelines. *SetX880d. $109.00. Book and CD are also sold separately for $60 each.*

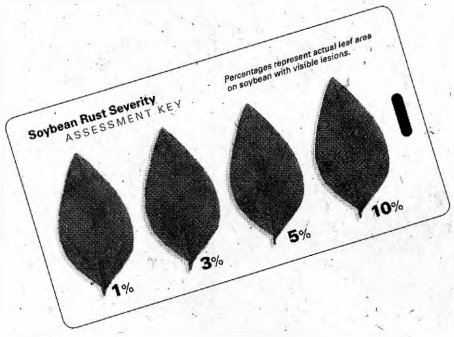


Pocket Guide to Crop Development

This handy pocket guide offers full-color illustrations and succinct descriptions of growing stages across the season for corn, sorghum, soybean, and wheat. It puts the key details for these four major crops into one pocket-sized package, eliminating the need for multiple references. Printed on water-resistant, tear-resistant paper for durable field use. *C1389. $2.25.*

Pocket Guide to Soybean Diseases in the Midwestern U.S.

This is a great tool to help crop scouts, farm managers, and producers choose the best disease management strategy. The laminated guide covers 24 common soybean diseases and offers targeted, practical information on background, disease agent, symptoms, time of occurrence, conditions that favor disease, and management planning. Color photos are included with each disease description for accurate identification. The sturdy construction makes the guide perfect for use in the field. *C1380. $16.50.*



Soybean Rust Assessment Tool

This durable, laminated card is designed for use in the field when you are scouting for soybean rust. One side of the card shows 1%, 3%, 5%, and 10% infected leaf tissue with lesions, which you can then compare to the leaves in your field. The reverse side of the card describes the correct assessment steps. Includes a clip-on holder and lanyard. *X881. $9.99. Also available: 20x folding pocket magnifier with carry case. X882. $32.99*

Order these products and more online at pubsplus.uiuc.edu